# COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

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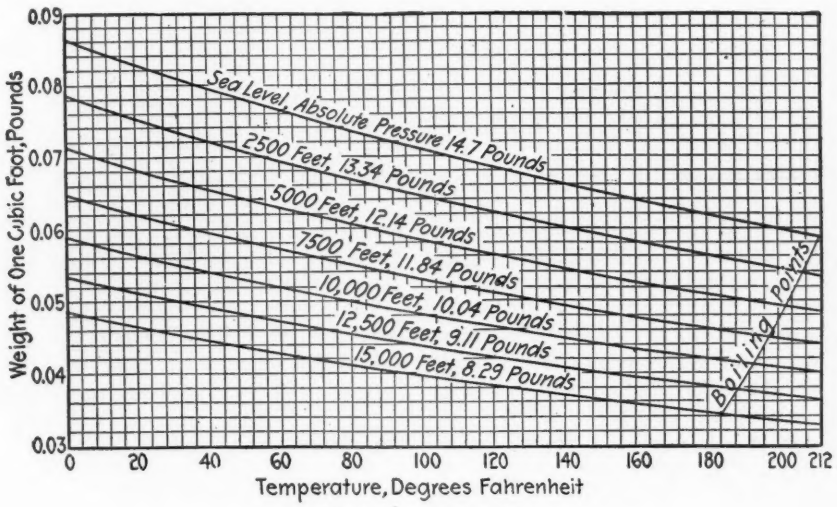



FREE AIR BY WEIGHT.

## COMPRESSED AIR BY THE POUND

BY FRANK RICHARDS.

In statements and computations having to do with the compression and transmission of air the basis or unit of quantity is the volume, usually in cubic feet, of free air, or air at atmospheric pressure, at the time and place under consideration. There are some inconveniences and uncertainties about this practice because the value of the unit is constantly varying with both the altitude, or normal local pressure, and with the temperature. This working volume can always be compared with what would be the volume at sea level and at average temperature, say 60 deg. F., but it is an unwelcome operation.

Knowing the actual quantity of air handled at any time and place would be working with more certainty. If the actual weight of the air is known, it remains the same, whatever the transformations of condition. Pressure, volume and temperature may all vary, but "a pound's a pound for a' that."

To facilitate using the weight basis for records and computations the accompanying table and diagram have been prepared. Computing the items of this table was simple. The weight of a cubic foot of air, whether compressed or not, is obtained by multiplying the constant 2.7093 by the absolute pressure and dividing the product by the absolute temperature. Thus the weight of 1 cu. ft. of air at an altitude of 10,000 ft. (absolute pressure 10.04 lb.) at 80 degree F. is

$$\frac{2.7093 \times 10.04}{80 + 461} = 0.0502 \text{ lb.}$$

The diagram embodies all the data com-

WEIGHT OF 1 CU.FT. OF FREE AIR AT VARIOUS ALTITUDES AND TEMPERATURES.

| Temperature Fahr. | Sea level Abs. press. 14.72 | 2500 ft. Abs. press. 13.34 | 5000 ft. Abs. press. 12.14 | 7500 ft. Abs. press. 11.84 | 10,000 ft. Abs. press. 10.04 | 12,500 ft. Abs. press. 9.11 | 15,000 ft. Abs. press. 8.29 |
|---|---|---|---|---|---|---|---|
| 0 | 0.0863 | 0.0785 | 0.0713 | 0.0648 | 0.0589 | 0.0535 | 0.0487 |
| 10 | 0.0845 | 0.0768 | 0.0698 | 0.0635 | 0.0577 | 0.0524 | 0.0477 |
| 20 | 0.0827 | 0.0752 | 0.0683 | 0.0622 | 0.0565 | 0.0513 | 0.0467 |
| 30 | 0.0811 | 0.0737 | 0.0669 | 0.0609 | 0.0554 | 0.0503 | 0.0457 |
| 32 | 0.0807 | 0.0734 | 0.0667 | 0.0606 | 0.0551 | 0.0501 | 0.0455 |
| 40 | 0.0794 | 0.0722 | 0.0656 | 0.0596 | 0.0542 | 0.0493 | 0.0448 |
| 50 | 0.0779 | 0.0708 | 0.0643 | 0.0585 | 0.0532 | 0.0483 | 0.0439 |
| 60 | 0.0764 | 0.0695 | 0.0631 | 0.0574 | 0.0522 | 0.0473 | 0.0431 |
| 70 | 0.0750 | 0.0682 | 0.0619 | 0.0563 | 0.0512 | 0.0465 | 0.0423 |
| 80 | 0.0736 | 0.0669 | 0.0608 | 0.0552 | 0.0502 | 0.0456 | 0.0415 |
| 90 | 0.0723 | 0.0657 | 0.0596 | 0.0542 | 0.0493 | 0.0448 | 0.0408 |
| 100 | 0.0710 | 0.0645 | 0.0586 | 0.0533 | 0.0484 | 0.0440 | 0.0400 |
| 110 | 0.0697 | 0.0634 | 0.0578 | 0.0523 | 0.0476 | 0.0432 | 0.0393 |
| 120 | 0.0685 | 0.0623 | 0.0565 | 0.0514 | 0.0466 | 0.0424 | 0.0386 |
| 130 | 0.0674 | 0.0612 | 0.0556 | 0.0506 | 0.0459 | 0.0417 | 0.0378 |
| 140 | 0.0662 | 0.0602 | 0.0549 | 0.0497 | 0.0452 | 0.0410 | 0.0373 |
| 150 | 0.0651 | 0.0592 | 0.0538 | 0.0489 | 0.0444 | 0.0404 | 0.0367 |
| 160 | 0.0641 | 0.0583 | 0.0529 | 0.0481 | 0.0438 | 0.0397 | 0.0361 |
| 170 | 0.0631 | 0.0573 | 0.0521 | 0.0473 | 0.0431 | 0.0391 | 0.0358 |
| 180 | 0.0621 | 0.0565 | 0.0513 | 0.0466 | 0.0424 | 0.0383 | 0.0348 |
| 190 | 0.0612 | 0.0556 | 0.0504 | 0.0459 | 0.0417 | 0.0379 | 0.0343 |
| 200 | 0.0602 | 0.0547 | 0.0497 | 0.0452 | 0.0411 | 0.0373 | 0.0338 |
| 210 | 0.0593 | 0.0539 | 0.0489 | 0.0445 | 0.0405 | 0.0368 | 0.0332 |
| 212 | 0.0591 | 0.0538 | 0.0488 | 0.0444 | 0.0404 | 0.0366 | 0.0331 |

prised in the table, while the curve at the right hand, where it cuts the altitude curves, gives the boiling points of water at those altitudes.

The diagram shows at a glance the difference in weight, or in the actual quantity of air handled, at the different elevations. Thus, to take the extremes, the weight of a cubic foot of free air at sea level and at 60 deg. is 0.0764 lb., while at an elevation of 15,000 ft. the weight of the same volume and at the same temperature is 0.0431, this latter being only 56 per cent. of the former.

In compressing this air to say 100 lb. local gage pressure, the compression at sea level would be $(100 + 14.7) \div 14.7 = 7.8$ atmospheres or compressions, while at 15,000 feet it would be $(100 + 8.29) \div 8.29 = 13.06$ atmospheres or compressions. This at once suggests the greater desirability of two-stage compression at the higher elevation.—*Power.*

## MEASURING THE FLOW OF AIR IN PIPES

BY G. G. CREWSON.

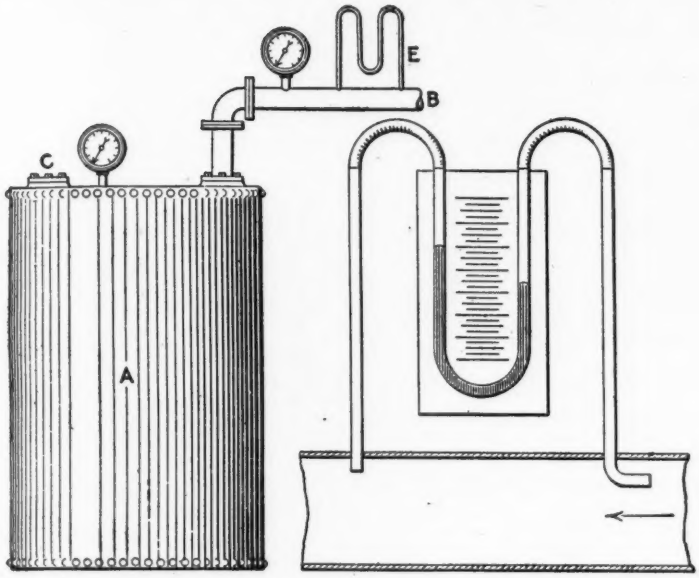
Some time ago, in a large mill where it was desired to make a proper cost distribution for the compressed air supplied to the various departments, the problem arose of measuring the air velocities in the different pipes. These velocities varied from 500 to 5,000 ft. per minute with the air under a pressure of about 80 lb. per square inch and as dry as can be obtained in a large compressed-air system.

The pitot tube was considered to be the most convenient device for the purpose, and in order to determine the accuracy of the various arrangements, an apparatus was fitted up as shown in Fig. 1. The air was admitted to the large tank *A* through the pipe *B* and escaped through an orifice at *C*. Pressure gages showed the pressures at the pitot-tube connection *E* and at the discharge orifice. Different-sized orifices were used in each case, these having previously been calibrated and the flow per minute under a tank pressure of 80 lb, per square inch was determined as follows:

| Diameter of orifice, inch | Cu. ft. of air per min. |
|---|---|
| ⅜ | 191 |
| ½ | 340 |
| ⅝ | 532 |
| ¾ | 765 |

The pitot tube was inserted in the supply pipe at a point not less than 20 diameters away from the tank or from any bend or fitting in the pipe that would tend to cause eddy currents. Various sizes of supply pipes were also used.

The two sides of the pitot tube led to an ordinary form of U-tube, and at first this feature was troublesome as difficulty was experi-



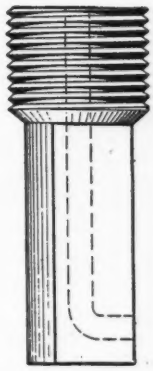



FIG. 1. ARRANGEMENT OF APPARATUS

FIG. 2. FIRST FORM OF PITOT TUBE USED

FIG. 3. FINAL FORM OF VELOCITY TUBE

enced in maintaining tight connections. This was finally overcome to a large extent by making a special form of U-tube with well packed connections and leads of ⅛-in. pipe.

The form of pitot tube first employed was but a piece of ⅛-in. brass pipe bent as shown in Fig. 2. The pressure side extended slightly inside the wall of the supply pipe. This form proved very unsatisfactory, giving varying results for the same conditions.

The next change was to make the velocity tube a straight pipe instead of a bent one. This projected directly into the supply pipe and was plugged at the end with a ⅛-in. hole drilled in the side facing the flow. The results in this case were but little better than before. The opening was then changed to $^1/_{16}$ in, without materially affecting the observations.

Many modifications were made in the form of pitot tube used until the one shown in Fig. 3 was adopted. This tube was brass, turned and threaded to correspond to a ⅛-in. standard pipe to the point where it screws inside of the air pipe. Within the air pipe it has the form of a wedge with a knife-edge, the edge facing the flow, hence offering little resistance. The opening through the tube and the outlet facing the flow were $^1/_{16}$ in. in diameter.

These tubes were made in a number of different lengths for different sizes of pipe in order that the opening at the edge might always be near the center of the pipe. The pressure side of the pitot tube was also found to give better results if it did not extend within the pipe but was just flush with the inside.

With this arrangement very accurate results were obtained. At one time, with velocities ranging from 500 to 5,000 ft. per minute and in pipes from ¾ to 2 in. in diameter, an average of 50 obserations showed, when the velocity was calculated by the formula $V = \sqrt{2gh}$, an average error of less than one-half of 1 per cent. and a maximum error in a single observation of less than 2 per cent.

As explained, this arrangement was first used with an ordinary U-tube but as this can give instantaneous readings only, and in many cases the flow to be measured was very irregular, a recording differential-pressure gage was substituted. By this means records could be kept of the flow of air to any department over any length of time. Line leakages were also quickly detected by means of this record.

For pipes of 1¼ in. diameter and larger, the brass velocity tube was screwed directly into the wall of the pipe, but for smaller sizes

standard tees were used, the upper branch being plugged and the plug tapped to admit the pressure and velocity tubes. The tee was then filled with lead and drilled to correspond with the diameter of the pipe with which it was to be used.

In applying this arrangement to an air line, two conditions must be met in the connections leading to the U-tube: First, all connections must be perfectly tight. Any leakage, particularly on the velocity side, due to the small opening, will introduce a large error. Every joint should be carefully tested with a soap solution for leakage and if a bubble is observed the joint should be made tighter. The second condition is to have the connections come from the top of the air pipe or, if from the side, have them pitched up at first so as to drain any entrapped water back into the air pipe. If these two conditions are observed, the U-tube or differential-pressure gage may be placed at some distance from the tube connections.

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## WELDING HIGH PRESSURE PIPE LINES

[The following we condense from a paper read before the Pacific Coast Gas Association at San Diego, September 1912, by Leon B. Jones, Assistant Engineer, Gas Department, Pacific Gas and Electric Company, San Francisco. It gives a clear and interesting account of the welding of line piping for high pressure gas transmission, and as the pipe after the welding was tested, as stated, at a pressure of 150 lb., the welding operation is, of course, equally applicable to compressed air pipes.]

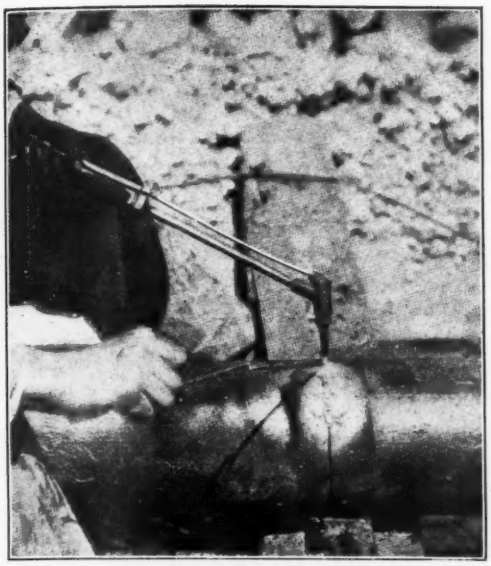
Heretofore the couplings or joints have been the short-lived part of high-pressure pipe lines. In practically all the couplings now in use, a compressible elastic gasket is necessary. Rubber has been used in joints of most of the pipe lines in California, but as the short time in which rubber loses its elasticity is greatly decreased by the rotting effect of the compression liquids of the gas, the life of rubber gasket joints is very much less than the life of the pipe. Pipe lines have been abandoned or removed, because the elasticity of the rubber in the joints was gone, and every coupling was a leak, and still the pipe, if undisturbed, would have had a considerable life. In some cases the gaskets were removed after several years, and the pipe was still in good condition. Up to the present time the life of high-pressure pipe lines laid in the average soil has been the life of the joint. With the recent developments in oxy-acetylene welding, a new era has been reached in the transmission of gas under high pressure. It is now possible to lay a pipe line without couplings of any sort, a steel-to-steel tube in which the joining of the lengths is of the same material as the pipe.

Welding with the oxy-acetylene torch has been successfully done in the large shops for several years, but the recent installation of an 8-in. high-pressure line in San Francisco is unique in the adoption of this process to the welding of high-pressure gas mains. The oxy-acetylene torch develops a flame temperature which may conservatively be estimated at 6,000 deg. Fahr., and it may readily be seen that with this temperature concentrated in a small pencil flame, under perfect control, that all the metals become amenable to the will of the operator. The welding of iron, steel, copper or brass is accomplished with greater ease and rapidity than the soldering of tin. When this powerful little flame impinges on steel, the metal becomes molten in a few seconds.

The recent installation of approximately 5,000 ft. of 8-in. steel tubing in San Francisco, in which the oxy-acetylene welding was used on every joint, was laid under the most difficult conditions, and afforded an excellent opportunity for practically testing the adaptability of welding to high-pressure gas mains. This line was laid in Geary street at the same time the municipal railroad was under construction, and this, necessarily, caused many obstructions and difficulties, but in every case the oxy-acetylene welding proved itself equal to the occasion, and all difficulties were surmounted.

There are three separate methods in which pipe may be handled when welding with the oxy-acetylene torch. Bell holes may be dug as for any coupling, and the pipe welded in the ditch, or the pipe may be lowered into the ditch and turned while the welds are being made; thus the welding of many of the joints is done on the top of the pipe, and the necessity for digging large bell holes at every joint is avoided.

The third method, which was found to be the most practicable, where conditions will allow, is to put short pieces of timber across the top of the ditch at intervals and roll the



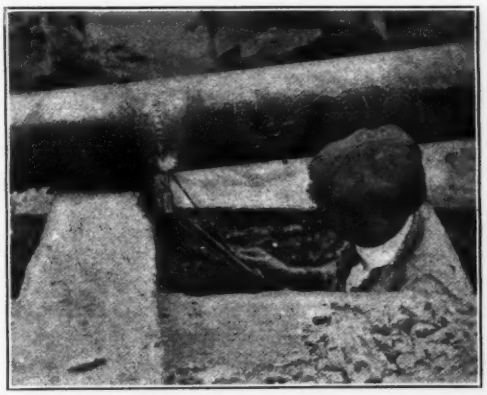
BEGINNING WELD ON TOP OF PIPE.

pipe into places directly over the ditch. This method insures a good alignment of the joint, and requires the least labor. With this method two men can turn as much as 500 ft. of pipe, while the operator is welding the joints, and as 500 ft. is about as long as can be conveniently handled, it will thus only require a bell hole and a weld in the ditch every 500 ft. While it is possible to make a good weld without turning the pipe, a great deal more time and care are necessary than when the pipe is turned, and the welding is always done on the top of the joint. In welding the under side of a joint in the ditch it is not possible to pile up the metal, as when welding is done on top of the joint. A joint being welded in the ditch is also more often allowed to cool before the weld is completed, and this leaves a possibility of pin holes where the weld is commenced again.

To insure against the possibility of the weld not extending through the entire thickness of the pipe, the ends of the lengths to be welded were left about ⅛ in. apart, and the operator worked with a rod of $^{5}/_{16}$ in. Norway iron in his left hand. This iron is melted into the joint to take care of the gap, and also to build up the metal around the joint. In this way the ends of the pipe are perfectly welded, and the metal at the joint is thicker than in the pipe, thus making the joint the strongest part of the line. To prove this statement that the weld is as strong, if not stronger, than the rest of the pipe, sample welds were made, and the pipe was afterwards flattened and bent until it was broken. In every case the break occurred back of the weld in the pipe and not across the joint.

A more practical test, which will appeal to gas men, was also made as follows: Two 40-ft. lengths were supported on timbers laid across the ditch, and the ends welded together. All the supports were then removed from under one of the lengths, and the entire weight of this 40-ft. length was suspended on the joint. The weld was in no way affected by this severe treatment. After several hundred feet of pipe are welded into a section, the supports are removed one at a time, and the pipe is reeled into the ditch like so much cable. Careful handling is no longer necessary, as a weld, if properly made, will stand the same treatment as the pipe, and any defect is better detected before the pipe is covered.

It may be readily seen that when welding the pipe on top of the ditch into sections several hundred feet long it is possible to work several welding outfits at the same time, with the minimum of labor. If a little care is exercised in distributing the pipe along the ditch, two men can readily roll it into place, over the ditch, for welding. In many cases, after these sections were reeled into the ditch, the ends of the sections were several feet apart. To avoid using a short piece of pipe and making two welds, a block and tackle was used, and with an automobile for a motive



WELDING ON UNDER SIDE OF PIPE.

power, these sections, in some cases 500 ft. long, were dragged several feet in the ditch to meet the end of the next section.

As the tubing which was used on this line was approximately $^{3}/_{16}$ of an inch thick and would not permit of threading, the question arose as to how valves or governors should be connected. This was solved in a very simple manner. A short piece of 8-in. standard pipe was threaded onto a standard flange. The standard pipe, which was 8 in. inside diameter, was then slipped over the tubing, which was 8 in. outside diameter. After the valve or governor was installed, and the flanges bolted up, the end of the standard pipe was welded to the tubing.

### THE PRESSURE TEST.

This installation, which represented about 180 joints, was welded throughout its entire length. At the end of each day's work the line was tested to 150 lb. pressure and allowed to stand over night. As an extra precaution the joints were also gone over with soapsuds. After completion the entire line was tested to 150 lb. pressure. The line stood at this pressure for three days without loss.

There are two general methods in which calcium carbide and water may be brought together for the purpose of generating acetylene gas—"water to carbide," or "carbide to water." Generators may, therefore, be classed as water feed or carbolic feed. In the early stages of the development of acetylene, most of the generators were of the water to carbide, or water-feed type. This was due to the fact that it was far easier to regulate the flow of liquids than of solids. However, practice has proven the carbide feed type to be the safest and also to produce the purest acetylene. In this type the carbide is fed into an excess of water, and therefore the temperature of the generators cannot exceed the boiling point of water, and the acetylene, in bubbling up through the lime water formed in the generator, is freed from most of its impurities. The heat produced from 1 lb. of calcium carbide and the slackening of the calcium oxide formed is sufficient to raise 4 lbs. of water from the freezing point to the boiling point. It is, therefore, essential that the water in an acetylene generator shall always be in excess. If a few general precautions are taken there need be no danger in the production of acetylene.

But the compression of acetylene is another story. One of the dreams of the early acetylene industry was that this gas might be safely compressed into a liquid form for convenient transportation and storage. This would appear to be an ideal condition, as acetylene liquefies at the comparatively low pressure of 700 lb. per square inch, and a cubic foot of liquid acetylene represents 400 cu. ft. of gas. This liquid is only four-tenths as heavy as water. It must be remembered that acetylene gas is an endothermic compound. In its formation heat is absorbed, and that spontaneous decomposition will take place, liberating this heat if subjected to abnormal temperature or pressure. Many violent explosions have occurred due to liquefied acetylene, and now acetylene compressed in open containers to a pressure exceeding two atmospheres (30 lb.) is considered a very dangerous material. However, calcium carbide represents a more condensed form of acetylene for transportation than the liquefied gas. A cubic foot of carbide represents about 500 cu. ft. of available gas, while a cubic foot of liquefied acetylene represents only 400 cu. ft. of gas.

Recent developments have also provided a substitute for liquid acetylene in what is known as dissolved acetylene. While acetylene is soluble in its own volume of water, its very great solubility in acetone has broadened the field of the uses of acetylene many fold. Acetone will dissolve 24 times its volume of acetylene at atmospheric pressure, and for each additional atmosphere to which it is subjected, a similar quantity will be dissolved; in other words, the solubility increases directly with the increase in pressure. Dissolved acetylene makes possible hundreds of uses of acetylene and the oxy-acetylene blow pipe, which would have been impossible before its discovery.

With the use of dissolved acetylene and oxygen under pressure, a complete oxy-acetylene welding outfit is very readily portable and ready for instant use and can be used in many places where a generator would be impracticable or impossible. When acetylene is dissolved in acetone it seems to be devoid of all possibility of an endothermic explosion under pressure. But the bulk of acetone is greatly expanded by this great absorption of acetylene, and it will readily be seen that any container used for acetone for the dissolving

of acetylene must be in capacity equal to the acetone expanded.

As the acetylene was used from such a container and the acetone contracted to its normal bulk, other spaces would be left above the liquid in which free or undissolved acetylene would exist, and thus create danger from explosion. This is overcome by the use of a porous solid which is inert to the acetone and also to the acetylene. Asbestos is adaptable for this purpose, and as it is from 75 to 80 per cent. porous the tanks can be packed to exclude all possibility of open spaces for free or undissolved acetylene, and yet leave the greater part of its capacity for acetone and dissolved acetylene. Calcium carbide can now be obtained at 5 cents per pound, and as a pound of carbide will produce 5 cu. ft. of acetylene, the cost of acetylene will be 1 cent per cubic foot at the generator; with an additional cost for compression if it is desired to use dissolved acetylene from tanks under pressure.

### PRODUCTION OF OXYGEN.

Until the introduction of the autogenous or oxy-acetylene welding practically all of the oxygen used in the United States was used for medical purposes and consequently exorbitant prices were obtainable. But since the entrance of oxygen into the commercial field many fertile minds have been busy with the problem of its economical production. Probably the most widely known method is from the reaction of certain chemicals. Oxygen is easily obtained by heating chlorate of potash or chlorate of soda, but as the reactions take place violently, with the resultant release of all the oxygen at once, the reaction is impeded by the addition of one-quarter part of dioxide of manganese. With the addition of the manganese dioxide, the oxygen is given off continuously until the reaction is complete. Another method is the use of chloride of lime and copper sulphate, with the addition of iron sulphate as a catalyzer. But as the use of chemicals for the production of oxygen is not feasible on a large scale and the economy limited by the price of the chemicals, other methods must be resorted to.

Oxygen may be very cheaply produced by the liquefication and distillation of air. The air is liquefied by high pressure and low temperature, and the oxygen and nitrogen separated by distillation due to their difference in boiling points. This is probably the most economical method of producing oxygen, as there is an unlimited market for the residual nitrogen as a fertilizer. This method requires an extensive and expensive outlay for equipment, and the market for oxygen has not, as yet, warranted the installation of such a plant in the United States, although oxygen has been produced in large quantities in this way in Europe for several years.

Acetylene gas of all the hydro-carbon gases most nearly approaches pure carbon. It is over 92 per cent. carbon and has a heat value of 1,685 B. t. u. per cubic foot, and this partly explains the remarkable temperature attained with the oxy-acetylene blow pipe. Acetylene requires for complete combustion 12½ times its volume of air, or 2½ times its volume of pure oxygen. If complete combustion were attained by burning acetylene with 2½ times its volume of oxygen the products of combustion would be carbonic acid and water.

However, it has been practically proven that the best welding results are obtained by the use of slightly over one and one-quarter volume of oxygen to one volume of acetylene, and with this incomplete combustion the products of the combustion change, carbon monoxide and hydrogen being formed instead of carbonic acid and water. To this formation of hydrogen, which surrounds and envelopes the point of welding, is attributed the fact that the oxy-acetylene has no injurious effect upon the metal.

The actual cost of the oxygen for the oxy-acetylene torch is materially less than would be calculated. The torch is constructed upon the injector principle in which the oxygen and acetylene are conveyed through separate tubes to within an inch of the point of combustion. The acetylene is usually conveyed direct from the generator through hose connections to the torch at a pressure of 3 to 5 lbs. The oxygen is stored in tanks and is used through a reducing valve and hose connections to the torch at between 15 and 20 lb. On the handle of the torch are controlling valves for nice regulation. The acetylene is first turned on full and lighted and then oxygen is added until the flame becomes a single cone. An excess of acetylene produces two cones and a white color, while an excess of oxygen produces a violet tint.

The hourly consumption of the torch used for 8-in. steel pipe was 24 cu. ft. of acetylene and 30 cu. ft. of oxygen. Using acetylene di-

rect from the generator at a cost of 1 cent per cu. ft. and oxygen from tanks at 6 cents per cu. ft., the cost of operating would be $2.04 per hour, and allowing 40 cents per hour for the operator, the total cost would be $2.44 per hour. As the average time necessary to weld a joint on top of the ditch, where the welding is done on the top of the pipe, is 10 minutes, the cost of such welds would be slightly over 40 cents per joint. The time necessary to weld a joint in the ditch, where the operator was forced to weld underneath the pipe, was 28 minutes per joint, making the cost of these joints $1.13 per joint. If the pipe is welded in long sections on the ground it is only necessary to have a weld in the ditch to every ten joints welded on the ground. This would make an average cost of 49 cents per joint. This would be approximately 2 cents per inch of circumference on steel pipe $^3/_{16}$ in. thick, and from this can be estimated the cost of welding different sizes and thicknesses, as the time per weld and consumption of oxygen and acetylene will be in proportion to the size and weight of the pipe.

## OUR WASTE OF COAL TAR PRODUCTS

Over a million tons of coal tar was recovered last year in Germany as a by-product of the coke and gas industries. This was an increase of over 100 per cent. in ten years, and represented a selling value of about ten million dollars. In Germany 90 per cent. of industrial works of this kind are now made to yield such products, as against something less than 20 per cent. in this country. In all others the coal tar is thrown away.

Foremost among these coal-tar products are benzol, tuluol, xylol, solvent-naphtha, ammonia, and the cyanides; next come pitch, anthracene, pyridia, naphthalene, the light, medium and heavy oils, and in further development etheric oils, perfumes, drugs and dyes. The work involved gives employment to an army of people of every grade, from the highly trained scientific expert and investigator, through the ranks of merchants, clerks and skilled mechanics to day laborers. We read:

Of surpassing importance is the recovery of ammonia from the gases in the form of the sulphate and of sal ammoniac. To-day Germany controls the world-market with an output of more than 410,000 tons of the ammoniac salts, having a selling value of over $25,000,000. Besides many chemical applications—as in the manufacture of explosives—ammonium is especially employed as a fertilizer.

Benzol is the mother substance of a large number of important aromatic compounds and of artificial dye-stuffs, besides its use as a solvent and purifier for numerous organic bodies, such as caoutchouc and gums.

Purified tuluol yields many dyes, and is used in making explosives, medicinal preparations, perfumes, and so forth. Cyanide has long been used in gold-washing, and is at present used in making "Berlin blue." These manifold constituents of coal tar are separated by means of the process known as fractional distillation, based on the fact that the various components possess specific boiling-points.

## FORMULAS FOR FLOW OF GAS

In a paper read before the Illinois Gas Association, Chicago, Mar. 21, 1912, Mr. J. M. Spitzglass gave the derivation of formulas for determining the flow of high- and low-pressure gas, based on modifications of Unwin's formulas, the constants being obtained from experimental data furnished by the engineering department of the People's Gas Light & Coke Co., of Chicago. These formulas are as follows:

For high-pressure gas,

$$Q=64.3V(PAD^5\div WLK);$$

For low-pressure gas,

$$Q=1910V(HD^5\div WLK),$$ in which

$Q$=discharge of free gas, cu. ft. per hour; $P$ =drop of pressure due to pipe friction, lb. per sq. in.; $A$=average absolute pressure, lb. per sq. in.,= (initial pressure+final pressure) $\div 2$; $D$=pipe diameter, in.; $L$=length of pipe, miles; $W$=specific gravity of gas (air=1); $H$=drop of pressure, in inches of water; $K = 1+(3.6\div D)+0.03D$.

## EFFICIENCY OF GAS COMPRESSORS

By P. F. Walker, Prof. Mechanical Engineering University of Kansas.*

Efficiency has many definitions and meanings. My theme in its entirety contemplates the type of gas compressor used so generally throughout the mid-continental field, consisting of the compressor itself and its driving

*Annual Meeting, 1912, Natural Gas Association.

engine of the internal combustion variety, and to it we may apply efficiency conceptions to the number of seven—perhaps more.

1. Volumetric efficiency, based as usual on the total actual volume of piston displacement filled to the full with gas of the pressure and temperature found in the intake line outside the inlet valves.

2. Mechanical efficiency of the compressor alone, perhaps better styled cylinder efficiency, relating to the work actually expended upon the gas to that required by a theoretical compression cycle with a suction line at full intake pressure, discharge line at even discharge—line, pressure, compression curve a perfect isothermal, and with no clearance. It fails of perfection by reason of clearance irregularities, loss in the valves, and fluid friction or head to produce flow into and out of the cylinder. It may be best expressed by a factor greater than unity, based on the theoretical power required.

3. Mechanical efficiency of the unit, or the ratio of the indicated powers in the compressor and power cylinders.

4. Thermal efficiency of the driving engine, based on the heat value of the fuel consumed.

5. Thermal efficiency of driving engine, based on the ideally perfect engine cycle under the existing conditions of fuel treatment.

6. Commercial efficiency of the unit, or economy, based on the handling of a stated amount of gas, fuel costs only considered.

7. Same as number 6, but including costs of attendance, upkeep and depreciation, etc.

This paper will emphasize the first two in the main, but will consider all excepting the last in more brief statement.

### VOLUMETRIC EFFICIENCY.

This is a factor in continual use by compressor men and its determination is of great importance. A method of doing this has been followed in recent work by the writer, which may be of some interest and will be given here.

The indicator is the only source from which such information may he gained, and the handling of the card is the principal point of the work. From it the volume changes of gas actually within the limits of piston travel may be found by direct measurement. In order to combine volumes with pressures in equations based on the gas laws the absolute volumes must be known, however, calling for the cylinder clearance volume, and in order to compare any two volumes of gas the temperatures must be known as well as the pressures. Volumetric efficiency being based upon the full displacement volume of intake gas at its existing pressure and temperature, it is clear that the temperature at points on the card must be determined first. The first step in this process is to find the clearance volume.

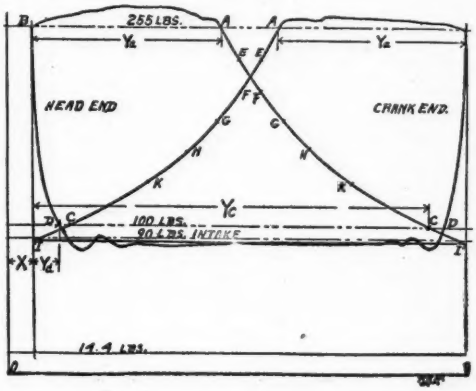



FIG. 1.

Referring to Fig. 1, a typical card is shown with two horizontal lines drawn across, one cutting the compression and re-expansion lines at points A and B, and the other at points C and D. The clearance volume is represented by the unknown distance X, while volumes of change, measured to the several points from the end of the card, are represented by the symbols Ya, Yb, Yc, Yd. The upper reference line, A and B, is usually taken at the discharge pressure as gauged in the main, for which position the valve of Yb will always be zero. The lower line C—D is located preferably at a few pounds above intake pressure, since the card often has certain irregularities at the latter level and it is essential that the points be on the true regular curves. The figure shows both head-end and crank-end cards, but the head-end one only is fully dimentioned. In taking measurements both cards have been scaled and the averages used in the calculations, in some of the work the averages from several separate cards being used directly. The points E, F, G, H and K, duplicated on both cards, are points at pressure levels 24 lbs. apart, at which points volumes are measured for subsequent work.

The equation of the compression curve, which will enter largely into the following work, may be taken in the form usual for all such calculations, namely:

$$P\,V^n = \text{Constant.}$$

For the purposes in view we may assume that the compression and re-expansion curves both have the same value for the exponent 'n' in this equation, hence for the curve between points A and C on the one, and between points B and D on the other, we write the equations

$$P_a\,V_a^n = P_c\,V_c^n$$

$$P_b\,V_b^n = P_d\,V_d^n$$

Dividing the first equation by the second, remembering that $P_a$ and $P_b$ are equal and that $P_c$ and $P_d$ are equal, we have

$$\frac{V_a^n}{V_b^n} = \frac{V_c^n}{V_d^n}, \text{ or } \frac{V_a}{V_b} = \frac{V_c}{V_d}$$

Now the true volume at A, designated as $V_a$ equals the dimension $Y_a$ scaled from the card, plus the unknown clearance X. Similarly with the other volume.

Substituting these values, we have

$$\frac{Y_a + X}{Y_b + X} = \frac{Y_c + X}{Y_d + X}$$

Reducing and solving for X we find

$$X = \frac{Y_a\,Y_d - Y_c\,Y_b}{Y_c + Y_b - Y_a - Y_d}$$

Returning now to the first quotation

$$P_a\,V_a^n = P_c\,V_c^n$$

We may substitute the numerical values found for $(Y_a + X)$ and $(Y_c + X)$ for $V_a$ and $V_c$.

In order to find the numerical value of 'n' we may write the original equation in the form

$$\frac{P_a}{P_c} = \left(\frac{V_c}{V_a}\right)^n$$

Taking logarithms,

$$\text{Log. } P_a - \text{Log. } P_c = n\,(\text{Log. } V_c - \text{Log. } V_a)$$

$$\text{from which, } n = \frac{\log P_a - \log P_c}{\log V_c - \log V_a}$$

Making the calculations indicated for four sets of cards in the last series which has been handled by the writer, one of which has been copied to make Fig. 1, two sets from one cylinder and two from the other cylinder of a compressor unit, clearance for one cylinder is found to be 5.41 per cent. and for the other 5.83 per cent. of the piston displacement. The average value of the exponent 'n' for the first cylinder is found to be 1.264, and for the second 1.275, the two averaging at 1.2695. In a former extensive series of calculations on about 80 indicator cards taken from sixteen compressors of four different sizes and of two different makes, with clearances ranging from 2.08 per cent. to 4.8 per cent. the average value found for the exponent 'n' was 1.33. The compressor which in this former investigation gave the largest clearance of 4.8 per cent. is the same compressor used in the last investigation when values of 5.41 and 5.83 per cent were found. This particular compressor has been modified since its installation, the piston having been turned off slightly to give more linear clearance inside the heads, thus accounting for the unusually large value.

Some surprise may be occasioned by reason of this exponent having so large a value on the actual card. It is customary to compare the actual curve with the theoretical curve which would be traced were the compression carried on in a cylinder made of non-conducting material, the walls of which could neither impart heat to the gas nor absorb it.

Such a theoretical curve, when the gas is a so-called perfect gas, has an exponent 'n' equal to the ratio of the specific heat at constant pressure to the specific at constant volume. These two specific heats for methane gas have average values over ordinary temperature ranges of 0.655 and 0.539 respectively, giving a ratio of 1.22.

Now in an actual compressor the gas loses heat to the cylinder walls and hence to the jacket water during compression, which tends to give a flatter curve with an exponent smaller than that for the ideal curve in the non-conducting cylinder. In seeking an explanation for the apparent paradox the writer took up the study of the physical laws of methane gas, taking into account the variations from a perfect gas, basing his work on the experiments of the French scientist Amagat. The work was somewhat complex, and is not repeated here, but the main results were as follows:

(a) For constant temperature changes, instead of following Boyles Law, P V = Constant, methane has the form of equation written in the above work with an exponent 'n' varying from .97 to .99 for different pressure variations.

(b) For constant pressure, instead of following Gay Lussac's Law of temperature varying in direct proportion to the volume, it follows an equation of the form

$$T = 138.1\ V + 41$$

the numerical values here used applying to a pressure of 100 lbs. per sq. in.

(c) For the ideal adiabatic curve followed in the non-conducting cylinder the exponent "n" has varying values for the different ranges of pressure, but for the usual conditions of natural gas compressor operations with intake pressure of about 100 lbs., it varies from 1.4 to 1.5 with different discharge pressures. This explains the fact of the cards' showing exponents larger than the specific heat ratio.

With the equation of the compression curves established, the ultimate aim is the determination of the true equivalent volume of gas handled by the compressor during a complete cycle, from which the volumetric efficiency is derived. An active influence in this determination of volume is the temperature of the gas during the compression stroke. No satisfactory direct method of finding this is available, and none may be possible, since it is the average temperature of the whole body of gas in the cylinder that is needed and this may be quite different from that near the metal walls. The following approximation has been carried out.

Temperatures on the compression curve will vary approximately according to the equation

$$\frac{T_a}{T_c} = \left(\frac{P_a}{P_c}\right)^{\frac{n-1}{n}}$$

This is assuming that gas follows the perfect gas law in this respect, and in most calculations this probably involves a smaller error than that incident to measurements from the indicator cards where measured values are used in calculations for absolute values, not for comparative values.

The temperatures of the gas at intake and discharge, in the pipe connections close to the cylinder, were 41 degs. and 185 degs. Fahr., respectively, for the times of taking the four sets of cards which form the basis for the present calculations. 460 degs. are to be added to the absolute temperatures, and the barometer during the test gave the atmospheric pressure as 14.4 lbs. The suction line was, by measurement, about 1.8 lbs. below the intake line of 90 lbs., and this value of 88.2 lbs. will now be used instead of the values at the arbitrarily fixed level of the line C-D of Fig. 1, the corresponding volume being full displacement volume plus clearance, or 5.524 cu. ft. For this point of beginning compression the symbols Pl, Vi, Tl will be used.

The temperature of the gas at the beginning of the compression stroke will be above that at the intake valves, due to the heating influence of the cylinder walls during the suction stroke. The inner surface layer of metal is at its highest temperature at the end of the preceding discharge stroke, and is cooled, of course, as its heat passes to the incoming gas. Similarly the discharge gas is cooled by the action of the metal and water combined during the remainder of the stroke following the opening of the discharge valves, so that the highest gas temperature exists at the end of the compresion curve proper, at point A on Fig. I. How much these two temperatures at the beginning and end compression are above the observed temperatures outside the valves is the question to be determined.

As a first step it is assumed that the temperature at "A," Fig. 1, is the same as that in the

discharge line. Solving the last equation noted above, with Ta = 64 degs. absolute, Pa = 269 lbs., Pl = 101.6, and with the average value of n = 1.2694, we find Tl = 525 degs. abs., which is 24 degs. above the temperature observed in the intake line. That is, under such conditions, the intake gas was heated 24 degs. during suction. This result indicates that the heating of the gas during suction will remain greater in number of degrees than the cooling during discharge by an amount somewhat less than 24 degs., as different values of temperature are assigned to point A. The problem before us then is to determine how much allowance in temperature is suitable for the cooling effects of the walls during the discharge period.

Studying the conditions affecting the heat transfer it will be apparent that the three most significant factors are:

(a) The period of time occupied by the process.

(b) The area of contact surface.

(c) The difference between gas and metal surfaces.

Since the valve head, which forms the real cylinder head in contact with the gas during discharge, or not water cooled, the most effective cooling surface is the cylindrical wall, so that the areas of contact are approximately proportional to the length of stroke traversed, as is also the time. That is the discharge being for nearly half a stroke, the time of a half stroke being nearly in proportion to the time for a full stroke, this relationship may be taken.

For the four sets of cards under consideration in the average length of stroke traversed after discharge begins is 1.926 in. on a card length of 4.38 in., or 44 per cent. of the stroke. From these two considerations, then, we would expect the drop in temperature during discharge to be 44 per cent. of the rise during suction, or 45 per cent. will be used since the cylinder head effects are relatively greater for the shorter stroke.

As to the third factor much greater difficulty is encountered in determining relative values, but it is believed that the following calculations throw light on the question:

The value of the exponent 'n' on the compression curve indicates whether heat is being added to or taken from the gas. On the compression curve an exponent less than that representing the adiabatic curve means that heat is being transmitted to the cylinder walls, and a larger value means that heat is passing from the walls to the gas. To test this matter, measurements were taken from the eight indicator cards at points designated as E, F, G, H and K, Fig. 1, the pressures and volumes averaged, and the value of the exponent calculated for each interval between points according to the method described for the larger portion A-C, with the following results:

Beginning at the point '1', beginning of compression, we find:

For portion 1—C, n = 1.415
For portion C—K, n = 1.242
For portion K—H, n = 1.316
For portion H—G, n = 1.287
For portion G—F, n = 1.273
For portion F—E, n = 1.270
For portion E—A, n = 1.250

The first value indicates that from 1 to C the curve is essentially an adiabatic, neither receiving nor losing heat on the average. Undoubtedly the gas receives some heat during the first portion of the distance and loses some during the latter. During the period the temperature rises about 27 degs., so that it is evident that the walls are down to approximately 20 degs. of the gas.

The last value, for the portion E-A of the curve, indicates that the temperature rose 60 per cent. of the amount that it would have risen on an adiabatic between the same pressures, or that heat was being withdrawn at the rate of 40 to 50 per cent. of the amount necessary to hold a constant temperature. This is equivalent to cooling the gas 4 degs. during the time involved, which means a rapid heating of the metal surface. No data is available to show what difference in temperature is necessary for the flow of this amount of heat, but the difference will diminish rapidly as the one substance rises and the other falls, and it does not seem unreasonable to expect that it will become not more than 20 degs. at the end of discharge—the same difference as at the end of suction. It is understood that these conditions apply to but a thin film of metal on the surface, the fluctuation growing less and approaching zero at a moderate depth.

Both periods of suction and discharge are thus seen to be under similar conditions. At the beginning of each the temperature difference is considerable but diminishes toward the

end, and it is not unreasonable to assume that the mean difference is approximately the same for both. This means that the heat transfer conditions indicate that the cooling during discharge is 45 per cent. of the heating during suction, and it has been shown that the difference between the two values will be somewhat less than 24 deg. We may therefore solve as follows:

(Temp. fall on Disch.) = .45 × (Temp. rise on Suct.)

(Temp. rise on Suct., — (Temp. fall on Disch.) = 23.5 deg., approx.

Then (Temp. fall on Disch.) = 19.25 or say 20 deg.

Temperature at point A may then be taken as 205 deg., or 665 absolute. The resulting temperature at beginning compression is then found to be 542 deg. absolute, or 82 deg. Fahr., and at the point C, 569 deg. abs. or 109 deg. Fahr. Having probable temperatures at points A and C, we may now compute the volumetric efficiency by first finding the equivalent volume at 90 lbs. gage pressure and 41 deg. Fahr.

Equiv. Vol. (from point A) = $2.296 \times \frac{269}{104.4} \times \frac{501}{665} = 4.45$ cu. ft.

Equiv. Vol. (from point C) = $4.514 \times \frac{114.4}{104.4} \times \frac{501}{569} = 4.37$ cu. ft.

Mean equivalent volume = 4.41 cu. ft.

Vol. Eff. = $\frac{4.41}{5.23} = .844$ or 84.4 per cent.

It is interesting to note that without the temperature correction the volumetric efficiency would have been found to be 87 per cent.

Referring again in pasing to the varying values of 'n' along the compression curve, the occurence of the low value, 1.242, on the portion C-K is somewhat paradoxical. It indicates rapid flow of heat to the walls. One explanation may be that saturated vapors below the temperature of 139 deg. at point K would make more rapid the flow of heat to the walls, which would change as the vapors became superheated.

### MECHANICAL OR CYLINDER EFFICIENCY.

While mechanical efficiency is usually understood to be the ratio between indicated horsepower and the actual brake horsepower at the engine shaft of applied horsepower at the compressor shaft, it is the thought here to include under the term the losses in the cylinder, as follows:

(a) Loss due to clearance.

(b) Friction in cylinder and valve passages, restricted flow of gas.

(c) Pressure necessary to open and hold open the valves.

(d) Excess of work actually done over that necessary for compression under constant temperature conditions. Since the compressed gas entering the transmission line quickly resumes the temperature of the earth, no advantage results from increased temperature.

(e) Power necessary to circulate cooling water, which should be charged against the cylinder. Approximate calculation only is possible. Should be added to indicated horsepower of compressor rather than to the work of driving the piston, since it is not a loss of power in the driving mechanism but stands in place of an increased card area which would result from the higher temperature in an uncooled cylinder.

No attempt will be made now to separate these individual items, excepting that the last is separate from necessity.

The standard indicator card is that with a true suction line at 90 lbs. pressure; isothermal compression to 225 lbs.; discharge along a true constant pressure line of 255 lbs.; constant volume drop, without clearance gas, to the intake pressure. The volume of gas drawn in during suction, which will be the total absolute volume, will be the true amount of gas handled in one cycle, and equal to piston displacement volume times volumetric efficiency of the actual cylinder. This is 5.23 / .844 = 4.414 cu. ft. The gas will be treated as a perfect gas, since for this range of pressure the equation for isothermal compression of methane would have an exponent 'n' equal to .98, against a value of 1.0 for a perfect gas, and the error involved is less than that in the card data.

The following calculation holds:

Vol. at end of compression = $\frac{104.4 \times 4.414}{269.4}$

= 1.713 cu. ft.

Work area = 144 (269.4 × 713 (1 + loge $\frac{}{269.4}$

$$\left(\frac{\qquad}{104.4}\right) - 104.4 \times 4.414) = 63{,}040 \text{ ft. lbs.}$$

Horsepower at 86.8 rev. per min.

$$= \frac{63{,}040 \times 2 \times 86.8 \times 2}{33{,}000} = 764$$

Work required to circulate the water is approximated as follows:

Water used in test for two cylinders = 310 lbs. per min.

Assume necessary head to be 40 ft., and efficiency of pumps as 50 per cent.

$$\text{Then h. p. required} = \frac{310 \times 40}{33{,}000 \times 50} = 0.75$$

Total i. h. p. from actual cards = 919.5.

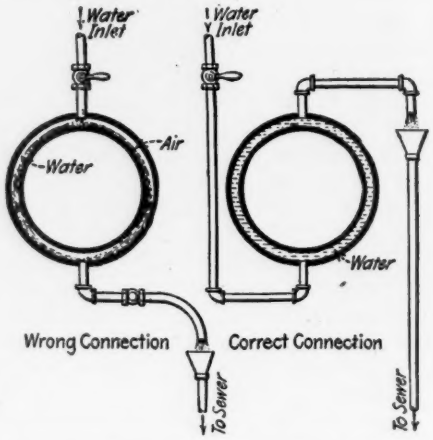
and with water h. p. added = 920.25.

Ratio, actual work to theoretical work = $\frac{920.25}{764} = 1.20$.

Losses aggregates 20 per cent. of theoretical power, or 17 per cent. of actual power.

This conception of efficiency has a direct significance when the compression of gas is treated as a means of producing line flow. The purpose of compression may be taken to be the production of line flow conditions, which involves the expenditure of energy to overcome resistance. The gas when discharged at the higher pressure into the mains is enabled, by virtue of the increased pressure, to supply the necessary energy, but it does so by drawing that energy from the ground in which the pipe line is buried and applying it, not by the expenditure of any internal energy imparted to it during compression.

The situation is as follows: The gas may come from the compressor at an increased temperature, but before it has applied any appreciable amount of energy in the producing of flow it drops to the temperature which it formerly had by radiation of heat to the earth or atmosphere. All that the compressor has done is to raise the pressure, the cylinder having received as much energy during the suction stroke as it expends in forcing the gas back into the mains after the discharge pressure has been attained, excepting in so far as losses above discussed change conditions. If the compressor adds heat to gas as well as pressure the heat is promptly dissipated and it stands as a compressor loss. The gas then proceeds to expand isothermally, drawing an amount of heat from the ground exactly equal to the energy imparted to the gas ahead, a process just the reverse of the compression process treated as the ideal. The efficiency value just found is, then, a direct measure of compression as a means of producing flow.

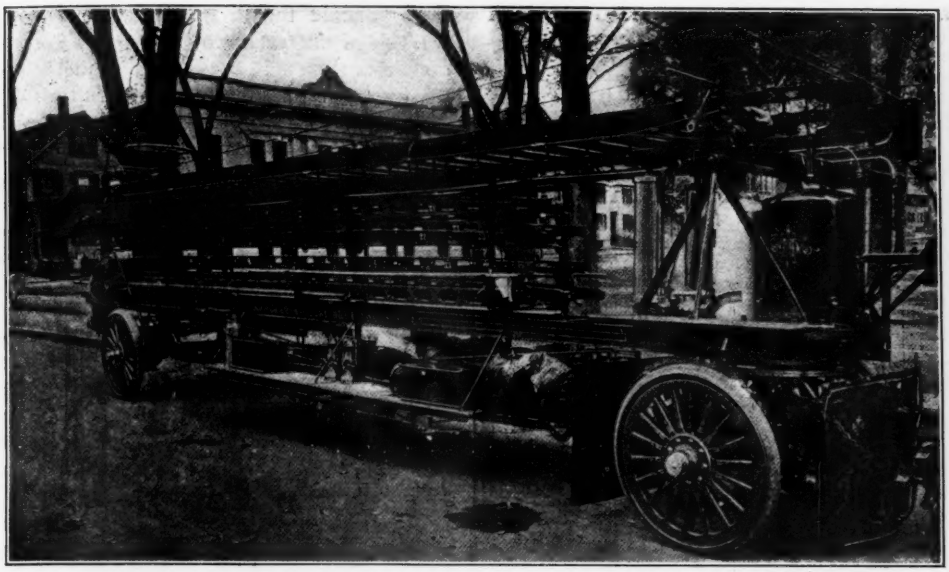



## WATER JACKET CIRCULATION

The following little story is told by a contributor to *Power*. He says:

"Soon after arriving in this country, I secured a position as general mechanic with a Canadian railroad. I could not speak English very well so experienced trouble in connection with my work. On one occasion I was sent to look at an air-compressor cylinder which was always running hot. The foreman was very upset over the case as a man had been working on it for three days and left the job with the cylinder in the condition he found it. The water connections were wrong, and after a half hour's work I changed them and the trouble ceased. I had considerable difficulty in explaining how the job was done, so I drew the sketch shown so that he could understand what I tried to explain. He was so pleased he told me to take the rest of the week off and go fishing."

The sketch shows up the matter very clearly and completely. With the first arrangement the jacket was not kept full of water, while after the pipes were changed it was necessarily entirely filled and all the surfaces were kept cool. The quantity of water required would not be as great as suggested by the overflow in the sketches. Only a very gentle flow is needed and then the water does not get very warm, but still it is indispensable.



PNEUMATIC ELEVATING TRUCK.

## LADDER TRUCK WITH PNEUMATIC ELEVATOR

The halftone here reproduced from the *Municipal Journal* shows a unique ladder truck in service at Manchester, N. H. The principal feature of the truck is an 85 foot extension ladder which in the original construction was raised by a screw-hoist which took considerable time to operate. A pneumatic hoist is now employed and the ladder can be swung to position in ten or twelve seconds. The application of the pneumatic device favored other improvements. The main ladder was formerly 36 inches lower and the other ladders were carried on top of it and had to be removed before it could be raised. This truck now carries, without interferring with the extension ladder, 10, 14, 16, 23, 25, 30, 35 and 50 foot ladders, two scaling ladders, one a 16 and the other a 14-footer, plaster hooks of various kinds, door openers, pitch forks, brooms, all kinds of rakes and other appliances. The truck is 65 feet long from the end of the poles to the end of the extension ladder, is 26 feet between wheel hubs and weighs, with driver and tillerman, about 11,000 pounds.

The hoist is carried upon the forward section and consists of two tanks and two lift cylinders and plungers. Air is compressed at the station by means of an ordinary motor-driven compressor, and at every filling the gauge on the larger and most forward tank is made to stand at 350 pounds. The second tank is filled with a special oil, called "zero oil" by the makers because of non-freezing properties. The presence of alcohol in the mixture can be detected from the odor of the exhaust after the ladder is raised. Air is admitted from the main tank into the secondary tank by means of proper valves, and it is usually found necessary to raise the pressure to about 225 pounds in lifting the ladder. The hoisting plungers work in heavy brass cylinders, pivoted at the base so as to follow the line of the ladder. An automatic valve is attached so that when the ladder reaches an angle of 45 degrees no further pressure can be transmitted to the liquid in the plunger cylinders. If desired, then it can be raised higher by opening a by-pass valve. With one filling of the main tank eight lifts to full height can be made and a correspondingly larger number of short lifts.

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Springs may be plated with nickel, but frequently will break when brass or copper plated. This is caused by the penetration of the hydrogen gas, given off during the plating, into the steel. It renders them brittle.

## A SELF CONTAINED DIVING OUTFIT

The diving outfit designed by Messrs. Drägerwerk of Lübeck, Germany, makes the diver independent of atmospheric air, by supplying him with oxygen and regenerating the air he expires. The outfit comprises an apparatus worn like a knapsack where the air circulating in the helmet and the diving suit is purified automatically of the deleterious gases produced by breathing and regenerated by an addition of oxygen. The diver thus has at his disposal 60 to 70 liters of air per minute, i. e., 3,600 to 4,200 liters per hour, which suffices for even the most exacting work.

The regenerating apparatus comprises steel cylinders filled with compressed oxygen, a potash cartridge and circulating arrangement, viz., a suction and pressure nozzle and a pressure reduction valve. It is connected with the helmet by two short lengths of hose, one of which serves to draw off any used-up air, while the other supplies fresh air.

The apparatus is started up by opening a valve which is very easily handled; it will work from 2 to 3 hours, in accordance with the personal skill of the diver and with the quantity of carbonic acid secreted by his lungs.

In the place of the usual lead ballast, the diver carries on his chest a weight constituted by steel bottles where compressed air or highly compressed oxygen is accumulated. Whenever the diver wishes to reach the surface without any outside help, he simply opens the valve of these bottles, thus causing air to flow into his outfit and to impart to the latter the required buoyancy. This is how in cases of emergency he will from any normal depth reach, in a few moments, the surface of the water. A safety valve actuated with any excess pressure prevents the diving outfit from bursting with any accidental rise from considerable depths. If on the other hand the diver happened to fall even to a small depth, his life would be seriously endangered unless some special safety device were provided. In fact, any sudden increase in pressure would throw the diver's body into the helmet, like the piston of an engine, while the congestion produced at the same time might cause the man to swoon, so as to be unable to prevent a catastrophe. In order to obviate this danger, the helmet of the new diving outfit has been made of a subtle and substantial India rubber fabric, protected by a metal cover against any mechanical injury. Should the diver happen to fall, the pressure of the water would compress not only the air in the outfit, but the air in the helmet, the India rubber fabric of which will yield in the same way as that of the outfit. While the diver thus would feel the sudden increase in pressure, he would experience it uniformly on all sides, which would first of all prevent congestion. He will thus be able, with full consciousness, to allow some air to enter his outfit from the ballast on his chest, thus re-establishing normal conditions at a moment's notice. A safety acting telephone, which on account of the feeble noise of the air circulating in the apparatus insures a very satisfactory connection, can be attached to the helmet. The telephone cable and signalling string can be combined in a safety cable for hauling the diver to the surface in cases of emergency.

The type of apparatus so far designed is destined for depths of 20 meters as a maximum. Apparatus allowing the diver to work at greater depths are in course of preparation.

The carbonic acid expired by the diver is absorbed in the potash cartridge attached to the knapsack apparatus where the air passes in succession some flat cups lined with numerous grains of potash and soda which absorb any trace of carbonic acid. The air thus freed from any deleterious gases produced by breathing reaches the suction and pressure valve, in order there to be regenerated with a supply of 2 liters of oxygen per minute. The air conduit supplying the fresh air to the mouth and nose of the diver, closes the cycle performed by air circulation. The diving outfit acts, both as a breathing bag and an air reservoir in critical moments.

A special feature of this apparatus is its allowing the diver to work for hours below the surface without any connection with the land or ship, whenever the safety string has been cut or the telephone connection interrupted. Any pumps and the men required for their operation are dispensed with, the diver carrying about with him the air supply required for his breathing. Moreover, there is no risk of the diving outfit becoming twisted with the air conduit; and the cost of operation is extremely low.—*Scientific American.*

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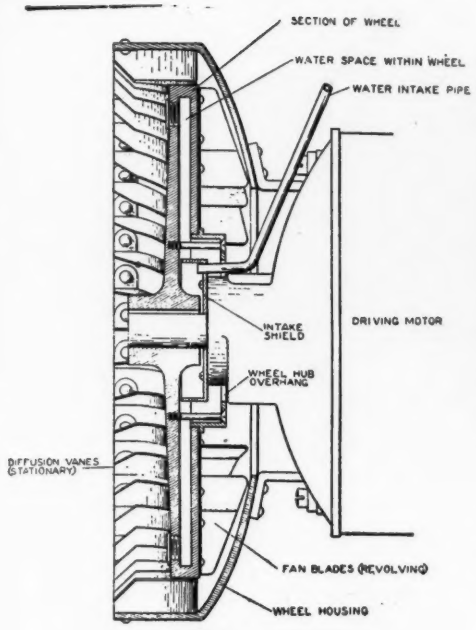
There are more than 200 miles of shafts, drifts, crosscuts and underground workings in the Calumet & Hecla mine.

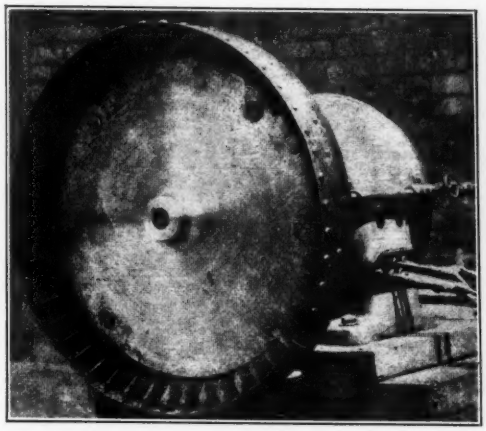



SECTION OF HUMIDIFIER.

## A MECHANICAL AIR HUMIDIFIER

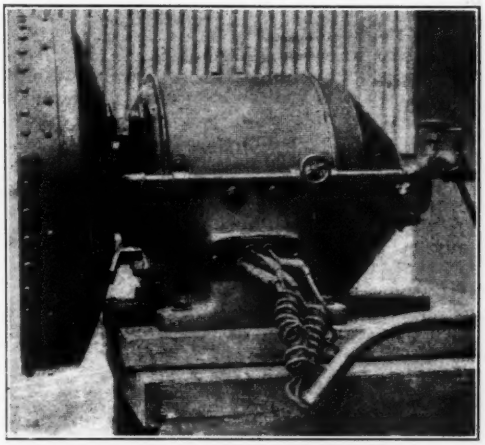
The illustrations show a device which has been developed by Mr. H. H. Clark, an engineer of the U. S. Bureau of Mines and on exhibition at the Pittsburgh testing station. By strictly mechanical means it produces a water mist almost fine enough to be called a fog.

The machine consists of a hollow wheel mounted upon the shaft of an electric motor. The wheel is provided at its periphery with spray nozzles, at its hub with an opening for the admission of water, and on its back with fan blades. The back and rim of the wheel is inclosed in a steel housing that serves as a casing for the fan, as a support for the air diffusion vanes, and as a shield for the revolving parts. When the wheel is rotated at normal speed by the motor, and water is admitted (under practically no pressure) to the opening in the hub, centrifugal force develops, at the nozzles in the wheel's periphery, an hydraulic pressure of more than 200 pounds per square inch. This pressure drives the water through the nozzles in the form of a fine spray which is seized, broken up still more, and finally carried away by the blast of air that the fan blades on the back of the wheel blow out all around the rim of the wheel between it and the surrounding housing. The diffusion vanes cause the air to be discharged in the form of a cylinder whose axis is coincident with the fan shaft.



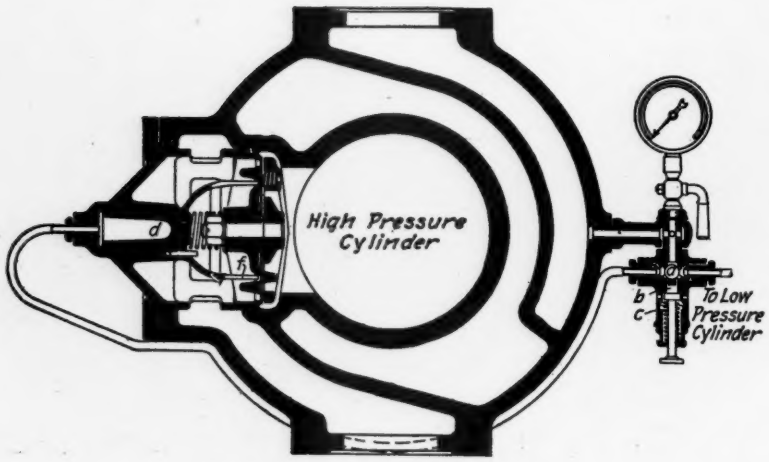
FRONT OF HUMIDIFIER.

As will be readily inferred, the mist produced is extremely fine and there is practically no dripping of solid water, but the apparatus has not yet reached its final form, and nothing can be stated as to its actual, practical accomplishment.



SIDE OF HUMIDIFIER.

What is perhaps the most extraordinary coal mine in the world, as well as the smallest, is situated on a tiny island in the Japan sea, near Nagasaki, and has just sufficient room upon its surface for the shafts and the hoisting machinery. The workings extend in all directions under the sea.




AUTOMATIC COMPRESSOR REGULATOR.

## AUTOMATIC AIR COMPRESSOR PRESSURE REGULATOR

The cut shows an automatic pressure regulator for a two-stage compressor of a Swedish air plant. In the regulator valve three passages come together, the upper passage communicating with the compressed air discharge piping, while the other two are connected with devices for closing the inlet valves of the cylinders. At the point of intersection of the three passages is placed a steel ball *a* held air tight against the opening of the upper passage by the spiral spring *c* pressing against the piston *b*. When the pressure of the compressed air on the ball exceeds the pressure of the spring, the ball is forced downwards, and compressed air, flowing into the two side passages, is led through small diameter copper pipes to the inlet valves of the high and low-pressure cylinders where it acts on the piston *d;* the grip *f* forces the valve plate from its seat and opens the valve; the low pressure cylinder is now connected with the external air, and the high-pressure cylinder with the piping leading to the intermediate cooler, while the open inlet valve connects both sides of the piston, so that the compressor takes only as much power as when driven at no-load. When the air pressure has gone down enough to permit the spring to drive the ball back against the opening of the upper passage, the admission of compressed air to the piston *d* is cut off, and the compressor starts to work again. By adjusting the spring *c*, the regulator may be regulated for any desired pressure.

## HOW EXPLOSIVES WORK

All commercial explosives owe their power of doing work to the expansive force of the great volume of gas into which they are converted at the occurence of the explosion. The pressure exerted by this gas in the drill hole or other confined space in which the explosion is brought about is what makes explosive substances of value in mining or other industries, and is the primary cause of all those manifestations of energy that follow the firing of a charge. Common black blasting powder, on explosion, produces about 390 times its own volume of permanent gases: 40 per cent. dynamite produces about 530 times its own volume of permanent gases; and nitroglycerin produces somewhat more than 747 times its own volume of permanent gases. These proportions of volume of gases to volume of explosive are those that would be found if the gases were measured under normal conditions of temperature and pressure, but at the moment of explosion the gases are highly heated, and therefore tend to occupy a volume much greater than the figures given above.

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A double-line tunnel four miles long is to be driven through the Selkirk range between Calgary and Vancouver, on the Canadian Pacific Railway in British Columbia. This tunnel will eliminate the possibility of interruption from snow slides, which have given a good deal of trouble in the Rogers Pass on the existing line.

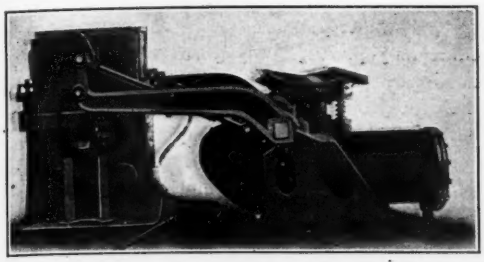

FIG. 1.

## A NEW COMBINATION MOLDING MACHINE

The accompanying halftones show a new jar-ramming, roll-over and pattern-drawing molding machine operated entirely by compressed air. The story of its cycle of operations is quite completely told by the illustrations.

The pattern-plate and stripping plate are fastened permanently on the table plate of the machine, the stripping plate being placed over the pattern and resting on the pattern plate. The flask is placed over the stripping plate and in Fig. 1 it is seen on the table of the jar-ramming machine filled with a sufficient quantity of sand and in position for ramming. This is done by jumping it up and down upon the table.

In Fig. 2 the mold is being rolled over ready to be squeezed. The squeezer head is moved forward and is directly over the flask. The air is applied to the cylinder and the table plate is pressed against the squeezer head and the top of the mold is squeezed as shown in Fig. 3.

After the mold is squeezed a lever is pulled

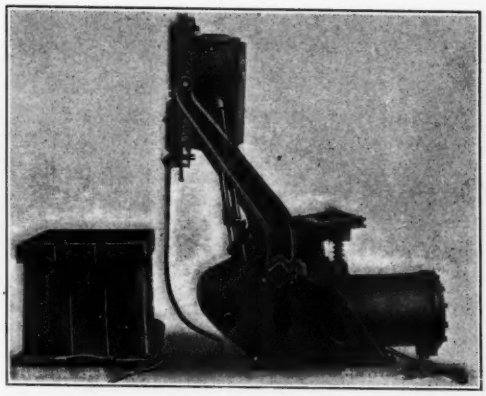

FIG. 2.

and the side lifting forks to which it is attached move upward and engage the stripping plate. In Fig. 4 is shown the stripping plate resting on the side lifting forks and when the air is released from the cylinder the pattern, which is fastened to the table plate descends. The pattern is thus stripped through the stripping plate, the squeezing head is thrown backwards and the flask is ready to be carried to the floor. The side lifting forks which support the stripping plate are lowered by means of the handle and lever to the first position ready for another mold, as shown in Fig. 5.

After the mold is squeezed the pattern can either be drawn through the stripping plate or, by drawing the handle forward, the flask can be stripped of the pattern, thus giving the choice of two different methods. In jarring, the table plate strikes upon a series of rubber and steel discs concealed in the base of

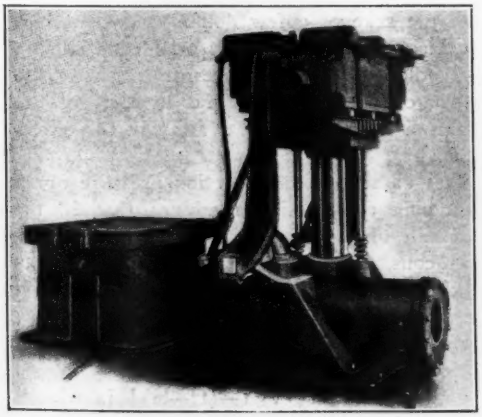

FIG. 3.

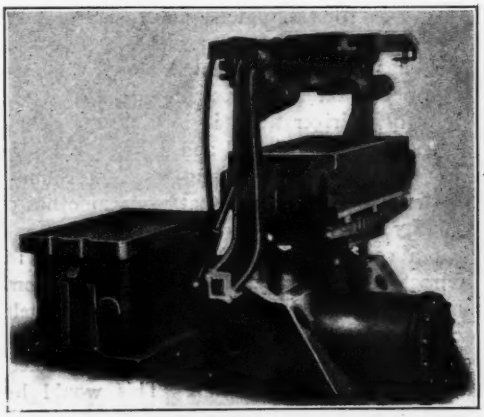

FIG. 4.

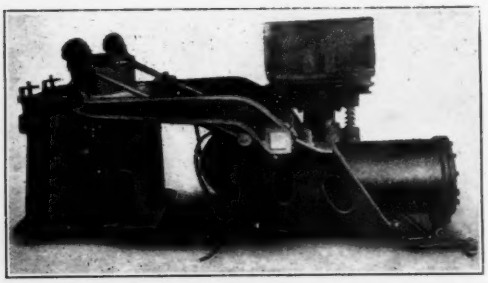

FIG. 5.

the machine. The dimensions of the table plate here shown are 30 by 45 inches, the lifting capacity is 5,000 pounds and the capacity of the roll-over is 4,000 pounds. Machines are made of various sizes both larger and smaller than this. The builders are the Herman Pneumatic Machine Company, Zelienople, Pa.

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## DIFFERENT WORKING PRESSUERS

This paper has to do entirely with compressors for refrigerating plants, but will be of interest to many of our readers. It was written by Mr. Robt. H. Karl, Chief Erecting Engineer Anheuser-Busch Brewing Association, St. Louis, and read before the Institute of Operating Engineers.

An ammonia compressor is constructed so that it takes in ammonia gas at a low pressure and temperature and discharges it at a higher pressure and temperature. The size and speed of the compressor, or strictly speaking, its piston displacement, is the measure of its refrigerating capacity.

If we speak of an ice machine of so many tons capacity it relates to the piston displace ment per minute of the compressor. The term "tons of refrigeration" is a mis-leading expression; it is too broad and admits of different interpretations, leaving room for misunderstandings. To say that a machine has a capacity of a certain number of tons, means that a certain quantity of ammonia gas will extract an equal amount of heat units from the brine tank as would be necessary to melt so many tons of ice at 32 degrees F. In other words the latent heat of fusion is taken as a basis of refrigeration. This would be justifiable if equal results were obtained under different conditions, but this is not the case, as, under peculiar conditions, a 50-ton machine may produce only 30 tons of refrigeration, while under more favorable conditions, it might produce 70 tons of refrigeration.

With an ice machine the question is: Under what pressures is a ton of refrigeration to be produced? If a compressor discharges a certain number of cubic feet of ammonia gas with the least expenditure of work, that is all the machine can do, so its efficiency depends on the pressure of the gas entering the compressor—and the pressure against which the gas must be discharged.

A pound of ammonia can either absorb or give off a certain amount of heat by changing its aggregate state; i. e., change from a liquid to gas, or *vica versa;* and, since a cubic foot of ammonia gas increases in weight when its pressure increases, it is evident that more refrigeration can be obtained if the incoming gas is under high pressure; also, since the amount of work which must be expended depends on the pressure against which the gas is discharged, the lower this pressure is, the less work required. In other words the nearer the two pressures are kept together, the greater will be the economy and capacity. Both pressures are governed by conditions; that is, temperature of the refrigerator and the pipe surface in one case, and pipe surface and temperature and quantity of the cooling water in the other case. These conditions govern the capacity and economy and should receive proper consideration when the plant is installed. Because this is very seldom the case, the capacity and economy of many refrigerating plants are impaired. Sometimes for the sake of a few dollars' worth of pipe surface, the entire plant is crippled, while, on the other hand, the compressor is entirely too large or too small for the work it has to do, and money is thrown away in this direction.

Let us see how the suction pressure of an ammonia compression machine; that is, the pressure of the gas as it passes from the cooling coils to the compressor cylinder, exerts such a marked influence upon the capacity and also upon the economy of the refrigerating machine. We will first consider the formula I for capacity which is:

$F=.00505\ N\ M\ [V\ 1-(tc-ta)]$ in which

F=Ice melting capacity.

N=Number of strokes per minute.

M=Weight of ammonia.
$r_1$=Latent heat just before evaporation.
tc=Temperature in condenser.
ta=Temperature in freezing coils.
.00505—A constant.

Since the number of strokes remains constant, it is evident that the capacity depends upon the weight of ammonia, latent heat of evaporation, temperature in the condensor and the low temperature in the freezing coils.

Referring to the table on Properties of Ammonia, it is seen that as the suction pressure is increased, the corresponding latent heat becomes less, and the corresponding temperature rises; consequently the latent heat, temperature in condenser and freezing coils change but little with different suction pressures and the capacity is practically proportional to the weight of ammonia circulated. Take, for instance, a suction pressure of 18.45 pounds absolute. The weight of a cubic foot of gas at that pressure is .0690 pound, while at a pressure of 38.55 pounds, a cubic foot weighs .1384 pound; or twice as much, and as the same volume of ammonia gas passes through the compressor in a given time, no matter what the pressure is, the weight of ammonia circulated is proportional to the weight of the vapor per cubic foot. Then, with the greater suction pressure the machine will circulate double the amount of ammonia that it will with the lower pressure and the capacity at the higher suction pressure will be nearly double than at the lower pressure.

It requires more aggregate power to operate the compressor at a higher suction pressure, but the increase in power is not proportional to the increase in capacity, because the power consumed per ton decreases as the suction pressure is raised. The power required is proportional to the heat delivered to the condenser minus the heat taken from the cold body, and the capacity is proportional to the heat taken from the cold body; therefore the ratio

$$\frac{\text{Horsepower}}{\text{Ice melting capacity}}$$

is proportional to the

$$\frac{\text{Heat delivered to the conderser—heat taken from body cooled}}{\text{Heat taken from body cooled.}}$$

The only effect on the heat delivered to the condensers of raising the suction pressure is to lower the temperature at the end of compression. The only effect on the heat taken from the body cooled is to decrease the latent heat of the liquid just before vaporization and to increase the temperature in the freezing coils, but since the temperature in the freezing coils increases faster than the latent heat decreases, the net effect of raising the suction pressure is to increase the heat taken from the cold body. Since the heat delivered to the condenser is decreased and the heat taken from the body is increased, the fraction

$$\frac{\text{Heat delivered to condenser—heat taken from body cooled}}{\text{Heat taken from body cooled}}$$

and the ratio

$$\frac{\text{Horsepower}}{\text{Ice melting capacity}}$$

is decreased by raising the suction pressure, which brings out the important fact that increasing the suction pressure increases both the capacity and economy of the machine.

The following examples will perhaps serve to make things a little clearer. We will take a certain size compressor; for instance, a so-called 50-ton compressor, to illustrate the amount of refrigeration which may be obtained under different conditions.

Case 1. For the sake of simplicity, consider a saturated-gas compressor working without superheating. A 12-inch diameter by 24-inch stroke double-acting machine, at 70 revolutions per minute, is rated at 50-tons. If this compressor works with a suction pressure of 10.31 pounds against a condenser pressure of 200 pounds (gauge pressure) each cubic foot of ammonia at 10.31 pounds pressure would weigh .0921 pound, and each stroke of the piston displaced 1.57 cubic feet of gas, the weight of which at that pressure would be .1445 pound. The example then would read like this: F. = .00505 × 70 × 2 × .1446 (560.39—(100—8) × .80 = 37.02 tons, while the horsepower would be about 76.2. So this machine would fall short of its rated capacity about thirteen tons.

Case 2. If the same compressor is operated with a suction pressure of 27.28 pounds and a condeser pressure of 170 pounds, the weight of ammonia discharged per stroke will

be .2366 pounds, and at the same speed the capacity of the compressor will be: F. = .00505 × 70 × 2 × .2366 (546.88—(91—14) × .80 = 62.88 tons; horsepower about 83.2. This example shows the foolishness of buying a machine of 50-tons capacity without knowing under what conditions it will have to work, for this compressor will develop its rated capacity only.

Case 3. With a suction pressure of 18.68 pounds and a condenser pressure of 180 pounds at the same speed and efficiency, and the example will read like this: F. = .00505 × 70 × 2 × .1903 (553.04—(94—4) × .80 = 49.81 tons; horsepower about 80.4.

Case. 4. The same compressor may, however produte a great deal more. In cooling wort in a brewery where the suction pressure is 44.72 pounds and the condenser pressure 180.43 pounds, the weight of ammonia discharged per stroke is ,3295 and the result is: F. = .00505 × 70 × 2 ⁄ .3295 (531.96—(94—30) × .80 = 88.15 tons; horsepower required about 91.2.

From the above examples it will be seen that the effects of increasing the suction pressure on the same machine, with same speed, are marked. Comparing, for instance, Case 3, where the compressor is working at its rated capacity of 50-tons of refrigeration, with about 1.6 horse-power per ton, with Case 1, where the same machine with the same speed, etc., is working at a lower suction pressure, with 2 horsepower per ton, it is seen that in Case 1 the capacity is reduced 26 per cent. while the horsepower per ton is increased 25 per cent.

Now, comparing Case 3 with Case 2 it is seen that an increase in the suction pressure from 18,68 pounds, Case 3, to 27.28 pounds, Case 2, results in an increase in the capacity of the compressor, at the same speed, etc., to 62.88 tons—an increase of practically 12 tons, or 26 per cent., while the horsepower per ton has decreased from 1.60 to 1.24, or about 22½ per cent. less power per ton.

In comparing Case 2 with Case 1 we find that raising the suction pressure from 10.31 pounds to 27.28 pounds resulted in increasing the capacity of the compressor 70 per cent. and power requirements only 9 per cent. In other words the extra 25.8 tons refrigeration are obtained at an expenditure of only 7 horsepower.

The volumetric efficiency assumed in this case is 80 per cent, which agrees closely with results obtained in practical tests. In some cases, of course, it is much more and in others less; depending upon how well the machine is designed and operated as well as the skill of the operator in keeping the machine in first-class condition. The principal and unavoidable losses are self reduction of the liquid and suction depression; other losses being in superheating, leaking of piston and valves, and excessive clearance, which can be reduced to a minimum.

In the above examples 20 per cent. was added to the theoretical horsepower to allow for losses of friction, etc.

Operate your machine with as high a suction pressure and low head pressure as possible to maintain your required temperatures. Make use of your indicator and learn to analyze the cards and you will be surprised at the defects discovered. An indicator card taken from an ammonia compressor indicates the work performed by the machine. By comparing the heat curve with the isothermal and adiabatic curves, the excessive clearance and re-expansion losses are indicated, as well as leaky or defective valves. Calculations can be made to show the extent of these losses. All of these items are very important if the machine is to be operated at its full efficiency, and the indicator should therefore be used frequently on an ice machine, as it tells immediately if there is anything wrong with the compressor or with the system in general. It is not necessary to make exhaustive and expensive tests on an ice machine, as the simple indicator card tells the whole situation.

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The miner's inch is defined by California law as equivalent to 1½ cu. ft. of water per minute through any aperture or orifice.

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A big factor in Winnipeg's industrial future, and one that will rank Winnipeg high as a manufacturing center, is the completion of the municipal electric development scheme, whereby 60,000 horsepower is now available for power for factory purposes. This power, which can be increased as necessity arises, is being delivered at cost, and naturally proving a considerable stimulus to industrial activity.

# COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

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## CHINESE AIR RECEIVERS

The account given on another page of our present issue of the oxy-acetylene welding of the successive joints of a long high pressure gas pipe line in California, cannot fail to have an interest to those who have to do with piping for compressed air service. It may be that while the economy and success of this pipe welding is conceded for work of a permanent character, such as is the laying of a gas main, it would not be equally applicable for compressed air lines, for these are often temporary and have to be taken apart to be sold when the job is done, or to be used somewhere else by the same owners. Many such pipe lines, even of quite large size are only for a year or so, but many are laid for much longer or for absolutely permanent service, and as to the use of the welding operation in any given case circumstances must determine.

But there is another view of this welding operation and its adaptabilities which is worth considering. It must be remembered that in the case recorded in the article referred to the work was all done in the street with makeshift contrivances to facilitate the work, and it is inevitably suggested that in a well equipped modern factory with everything arranged for comfort, convenience and economy the welding operation might have a much more extensive application in manufacturing processes and upon work surely of the most permanent and enduring character.

May not the day soon come—for things succeed each other rapidly now—when we will realize more completely the inefficiency of, and the absurd waste of material in, the riveted joint, and may not later the time come when riveting will be abandoned and samples of it become an exhibit in the museums? The writer lately stood with a young lady friend beside a high pressure steam boiler where the rivets were a protuberant feature. "How strong that boiler must be with so many big rivets in it," she remarked. "Why, my dear girl, every rivet represents a hole in the sheets and that part of the boiler is the weakest instead of the strongest part of it." This, of course, is always true. With double the thickness of metal and the added weight of the rivet heads the joint is the weakest part and weakens the entire structure by 25 or 30 per cent. And that is not all. The sheet is 25 or 30 per cent. thicker over its entire surface,

and the same percentage heavier, than it need be to equal the strength of the joint.

If we are in order we here make a motion to the effect that hereafter rivets shall be dispensed with and instead the welding of the edges of sheets to each other be employed wherever practicable.

And where is there a better place for such welding than in the making of air receivers? The receivers are the most defective detail of compressed air practice to-day, and that in other ways than as to the riveting, but with these we have here nothing to do. Getting rid of the rivets and making receivers of uniform and sufficient and reliable strength throughout should be a desirable achievement.

And then the Chinese part of it, suggested in our title above. It is well known that the Chinese have never used barrels as packages for their merchandise, and the reason that has been assigned for it is that they have never found a way of putting in the last head of the barrel without having a Chinaman inside to hold it up.

It is rather singular that the same charge can be brought against us and the way we make our air receivers, especially those of the smaller sizes which are the most numerous. These receivers are made with dished heads, which is evidently proper, and one head is placed with the convex face outward, which also is proper, best for both strength and looks, while the other head is set with the bulge of the head inward, a thing disgusting to any one with correct mechanical instincts, until he has become too familiar with it, and the only assignable reason for it is that they can't rivet in the head the other way without some one inside to insert and hold the rivets.

In our August issue was described how one of these receivers exploded by the sudden outward buckling of the Chinese head and the tearing out—not shearing—of the rivets. Only a short time later another receiver in the same neighborhood exploded in the same way, showing at least where was the weakest place in it.

This weakness and the other weaknesses of the too familiar type of air receiver may be eliminated by abandoning entirely the use of rivets. Weld up the shell and weld in—or on—the head, placing them both in correct position and making "every part as strong as the rest." We need not here go into the details of the work in any particular. The scheme is entirely practicable, and the one who first goes into it fully equipped for the business cannot fail to make of it a complete success and contribute to the safety of those who have to do with air or other fluids under pressure.

## NEW BOOK

ENERGY AND VELOCITY DIAGRAMS FROM LARGE GAS ENGINES; Their Use and Layout, by Paul L. Joslyn, 70 pages, 6 by 9 inches, 62 diagrams. Gas Engine Publishing Company, Cincinnati. Cloth, $2.00.

For cost of construction, and, if for nothing else, for the avoidance of costly reconstruction, the designer of large gas engines has to consider many things which on small engines are often left to be worked out after a first engine has been built. In this book the author gives the methods of laying out energy and velocity diagrams for large engines operating on blast furnace, producer or natural gas, with instructions as to their use, etc. The data given are the result of actual designing of this character on some of the largest engines built in America and Europe.

## TRADE PUBLICATIONS

POSITIVE PRESSURE BLOWERS, Vacuum Pumps and Exhausters, Albert J. Kelting Engineering Works, Brooklyn, New York, 16 pages, 6 by 9 inches. Illustrated description of line of blowers and compressors.

PUMP SLIPPAGE, its Cause and Prevention, Hill Pump Valve Company, Chicago, 24 pages, 6 by 9 inches, illustrated, inserted folded blue print diagram. The discussion of pump slippage leads to the matter of defective valves and a description of the Hill pump valves.

THE INDICATOR BOOK, Trill Indicator Company, Pa., 48 pages, 6 by 9 inches, numerous cuts. The indicator and all appurtenances are described, and instructions as to manipulation are given, with many indicator cards from different types of engines and samples of the different errors of practice likely to occur.

MALLET ARTICULATED LOCOMOTIVES, Record No. 72, Balwin Locomotive Works, Philadel-

phia, 44 pages, 6 by 9 inches, folded lengthwise. This interesting line of locomotives is described, with examples of different designs for special service, and beautiful illustrations of engines complete and ingenious sectional views showing internal details. The weight of the heaviest engine shown is 406,600 lbs. and the greatest tractive force 97,200 lbs.

MANILA ROPE, by C. W. Hunt, 52 pages, 6½ by 9½ inches, liberally illustrated. This pamphlet contains a great variety of valuable information upon the general subject of ropes, rope driving and power transmission with formulas, tables and data useful in mill engineering. C. W. Hunt Company, 45 Broadway, New York.

DE LAVAL STEAM TURBINES, Multi-Stage Type, De Laval Steam Turbine Co., Trenton, N. J., 120 pages, 6 by 9 inches, profusely illustrated with halftones. This is more than an ordinary trade catalog. A third or more is devoted to a discussion of the "speed compromise" problem, and the relative advantages of the several fundamental types of turbines are discussed. The book contains a chart accompanied by a steam scale by means of which the energy available from the expansion of steam between given limits can be read off directly as heat units, velocity of steam in feet per second, duty in foot pounds per thousand pounds of steam, and pounds of steam consumed per horsepower hour. Detailed descriptions of the De Laval turbines are given. Sent upon request to those interested by the De Laval Steam Turbine Company, Trenton, N. J.

## REGULATIONS FOR WORKERS IN COMPRESSED AIR

At the International Congress of Hygiene and Demography, recently held in Washington, D. C., papers discussing the nature of the disease and its prevention were presented both by physicians and engineers, and the following notes are taken from such a paper by Mr. Henry Japp, of S. Pearson & Son, Inc., New York.

In order to safeguard properly the interests of the workmen under compressed air, it is necessary to maintain strict discipline during the working hours. In the construction of the East River tunnels the following set of regulations, written in English, German, Italian, Slavish, Hungarian and Polish, were posted in conspicuous places. In addition to an enforcement of these rules, men working for the first time under compressed air were kept under close medical observation for a probationary period, and if there were any evidence of physical weakness the workman was not allowed to continue work under air.

### REGULATIONS FOR MEN WORKING IN COMPRESSED AIR.

(1) All men must be examined by the medical officer before conmmencing work in compressed air, and must not enter the airlock until passed by him. His advice should be taken in all cases of illness or accident, which should be reported to him immediately.

(2) All men must wear the doctor's pass badge where it can be seen by the timekeeper and locktender.

(3) No man should enter the airlock when sick or with an empty stomach.

(4) After an attack of illness, all men must report to the medical officer before returning to work in the tunnels.

(5) No nuisance will be permitted in the tunnels. A watercloset on the surface is provided for the use of workmen. The bladder should be relieved before entering the tunnels, and all workers are strongly advised to see that their bowels are opened every day.

(6) All men are advised to use intoxicating liquors sparingly or better, not at all, and to drink water sparingly while in the tunnels.

(7) Get fully 7 hours' sleep every 24 hours, if possible.

(8) While in the lock, as the pressure is raised, it is recommended to clear the passage between the ears and throat by continued swallowing.

(9) After coming out of the lock, all men are advised to drink warm coffee freely and to put on dry, warm woolen clothing.

(10) Avoid exposure to cold and do not exercise unduly for one hour after leaving the lock.

(11) Smoking in compressed air is dangerous and not permitted.

### PROPOSED RULES.

With the view of obtaining authoritative information on the subject, the commissioner of labor of the State of New York called upon those interested in compressed air work to submit their views to aid him in drafting a law regulating employment under com-

pressed air. In answer to this request the following set of rules was submitted by a self-organized body of twenty-one members, including prominent engineers, doctors and contractors:

(1) *Medical Examination.* — Before being allowed to start work in compressed air, all men should be examined and pronounced physically fit by the medical officer.

In event of a man being absent from work for more than three days owing to a sickness, he shall not resume work in compressed air until he has been re-examined and passed.

When a man is suffering from an ailment he should report himself to the medical officer, whose advice he shall follow.

(2) No alcoholic liquors will be allowed on the work.

(3) The workmen shall be supplied with hot coffee free of charge.

(4) The contractors will also provide for the men warm dressing rooms, bath room with hot water and a medical airlock.

(5) *Analysis of Air.*—Sufficient air shall be pumped into tunnel heading so that the percentage of $CO_2$ shall not be greater generally that $^1/_{10}$ of one per cent. above that of the air being compressed, and in order to insure good ventilation, the air supply pipes shall be carried as near to the face as may be practicable and necessary.

(6) Persons working in compressed air must be able to communicate with the power plant on the surface at any time through suitable signal apparatus.

(7) *Periods in Various Pressures.*—Up to 20-lb. gauge pressure, two five-hour shifts at the face may be worked.

From 20-lb. up to 32-lb. gauge pressure, eight-hour shifts may be worked with half an hour off for lunch.

From 32-lb. to 40-lb. gauge pressure, six hours at the face shall be worked, divided into two shifts of three hours each.

The periods to be taken for coming out of the various pressures shall be as per table:

Pressure between locks to be approximately half the gauge pressure at the face. The men will be held responsible for the due observance of the above rules.

An abstract of the amended New York law, which went into effect September 1, 1912, was printed in the issue of COMPRESSED AIR MAGAZINE for June, 1912.

ONE-STAGE DECOMPRESSION.

| | |
|---|---|
| 15 lb. gauge pressure | 1 to 3 min |
| 20 lb. gauge pressure | 3 to 4 min. |
| 25 lb. gauge pressure | 5 to 8 min. |
| 30 lb. gauge pressure | 10 to 15 min. |
| 35 lb. gauge pressure | 15 to 20 min. |
| 40 lb. gauge pressure | 25 to 30 min. |

TWO-STAGE DECOMPRESSION.

25 lb. gauge pressure, outer lock, 3 to 4 min.
30 lb. gauge pressure, outer lock, 6 to 8 min., with five minute interval between locks.
35 lb. gauge pressure, outer lock, 8 to 10 min., with ten minute interval between locks.
40 lb. gauge pressure, outer lock, 12 to 15 min., with fifteen minute interval between locks.

## NOTES

Four thousand tons of coal were put into the "Olympic" in 14¼ hours at Southampton recently. This is a record coaling feat for the port and a world's record. Thirty-two gangs of men were employed, an average rate of 288 tons per hour being maintained throughout the night.

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Baltimore is losing $102,200 a year from underground leaks in water pipes. This declaration was made by Water Engineer Whitman, who will include in his estimate of 1913 expenses of the Water Department a request for $15,000 for the establishment and maintenance of a sub-department to detect and repair these leaks.

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Thirty years ago the value of natural gas produced in the United States was less than $500,000. There are now nearly 30,000 wells, producing annually more than 500,000,000,000 cubic feet of gas, valued at nearly $75,000,000. Last year the output was 508,353,241,000 cubic feet, Pennsylvania being the greatest consumer, with 154,475,376,000 cubic feet.

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The famous greenheart tree of British Guiana is said to be the strongest, toughest and most durable wood in the world, and it has therefore been selected by the army engineers in charge for the construction of the miter sills in the great lock gates of the Panama canal. This wood is best able, it is said, to resist the dreaded teredo, so prevalent in tropical waters.

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The smoke nuisance costs the United States $500,000,000 a year, is the estimate given by the department of industrial research at the University of Pittsburgh. This damage consists in the defacement of buildings, tarnish-

ing of metals, damage to merchandise, injury to both human and vegetable life, increased cost of housekeeping and loss to manufacturers through the imperfect combustion of coal. The loss in Chicago alone is estimated at $50,000,000 a year.

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Unless a dog has long, shaggy hair a vacuum cleaner will suck out the fleas "as clean as a whistle." It has been actually tried with excellent results.

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The Ingersoll-Rand Co. is shortly going to bring out a new drill, to be called "The Bull Moose," which strikes us as being a very good name for a hard-slugging rock drill. While we are on this subject of nomenclature, it will be interesting to note that the Mexican miners call the jack-hammer drill the *chicharra,* the cricket. The operator is coming to be known as the *chicharrero.—Engineering and Mining Journal.*

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It has been known for some time that gases will pass through metals when they are highly heated, thus platinum at a red heat will allow air to pass through it. Iron is also permeable for hydrogen when hot, and even when cold to a certain degree. More recently, Charpy and Bonnerot show that nitrogen does not penetrate iron below a temperature of 800 deg. Cent. Hydrogen passes more easily, and at a temperature of 500 degrees a considerable action is noticed.

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Australia has many valuable hardwoods and among them one of the most remarkable is yate. It has been found that this is the strongest timber known. Its average tensile strength is 24,000 pounds to the square inch, equalling that of good cast iron. Many specimens are much stronger and one was tested up to 17½ tons to the square inch, which is equal to the tensile strength of wrought iron. The tree grows to a maximum height of 100 feet, and has sometimes a diameter of two and one-half or even three feet.

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The Russian destroyer Norik, is stated to have exceeded 36 knots on her official trials last month. The vessel, which is 336 feet long by 31 feet 6 inches beam, is of 1,280 tons displacement, and was built at St. Petersburg, the machinery consisting of A. E. G. turbines and oil-fired boilers, being supplied by the Vulcan Company, of Stettin. The designed speed was 35 knots, with 36,000 shaft horsepower, but both have been considerably exceeded. This vessel, should the report be correct, is the swiftest destroyer afloat.

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In 1910 the mines of the transvaal employed 257 steam-driven air compressors having 100,291 hp., there being an average of three 50-drill compressors on each mine. Formerly, all the air compressors were steam-driven, but now electric energy is furnished to all the mines by the Victoria Falls & Transvaal Power Co., Ltd., and electricity for air compressors has superseded steam.

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The formal opening of the Livingstone Channel, 12 miles in length, through the shoal waters of Limekiln Crossing at the mouth of the Detroit River, occurred, with imposing ceremony, on October 19. This deep channel has been excavated through solid limestone rock and affords a straight and safe passage for the immense vessel traffic of the Great Lakes. More vessels and a greater tonnage pass through it than any other waterway in the world. This channel, 4⅘ miles of which lie in Canadian waters, has been some years under construction by the United States Government at a cost of about $10,000,000.

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It has often been observed on return airways, where the air is warm and dry, that the lamps do not burn so brightly and the workmen become dry and thirsty. Tabe explains this by saying that the parched air absorbs the moisture from the body, and unless they have ample drinking water, their blood becomes thick and hot, resulting in feverish, painful lassitude. The same warm air, before reaching the lamps, has been absorbing water in its journey, and is thus so heavily charged with watery vapor that its oxygen is diluted, which results in dull and sickly lights.

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A writer in "Science" tells of an ingenious little skiff, about two inches long, which he constructed and provided with a piece of soap for the motor. The boat was of wood paraffined to repel the water. The soap formed the stern board of the skiff. The boat was placed in still water in a bathtub, and began to move as soon as the water came in contact with the soap. After gathering headway it

reached a velocity of two inches per second. The power was derived from the potential energy of the surface water film set free by the diminution of surface tension, this reduction being due to solution of the soap.

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Our whistle is blown by compressed air. Sometime ago the compressor was down for repairs and it began to look as though curfew would not blow that night, when I happened to have a thought. I had a motor driven triplex water pump running against 75 lb. pressure and the top of the air chamber had a ¾-in. pipe tapped in it. I connected a whistle to this, stopped the pump, drained the air chamber, then started the pump again and had 75 lb. of air with which to blow the whistle. —*Practical Engineer.*

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The molecular aristocrats of the chemical sugar sphere and the molecular anarchists from the plain of nitroglycerine are nearly as far apart as kings and slaves were, but an exchange reports that dynamite is to become a new form of plow, especially in the South. A Southern farmer conceived the idea of turning things upside down in this new way and he found that the size of the crops increased to such an extent, because the deep sub-soil was loosened up, that it paid for all the dynamite and more. One manufacturer of explosives sold 500,000 pounds to farmers in 1908, in 1911 he put out 3,000,000 pounds for this purpose, and this year it is believed the output will be 5,000,000 pounds.—*Louisiana Planter.*

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A mining-machinery salesman recently walked over to a city rock pit where rock for making roads was excavated and crushed. He gave the superintendent a cigar and began talking rock drills. The drills in use there were manufactured by the company he represented, but were apparently of extremely antique pattern. The young salesman with characteristic enthusiasm and fresh from talking with mine superintendents, began to tell the city official of a very efficient one-man drill that was making records for itself. He claimed that if the city would install the improved type, at least one-half the present force of men could be dispensed with. At this point the city official spoke up; "Young man," he said, "if you can give us a drill that will require more men to operate and make more jobs that aren't too hard, we'll be interested, but this new machine's not in our line.—*Engineering and Mining Journal.*

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## LATEST U. S. PATENTS

*Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.*

OCTOBER 1.

1,039,700. GLASS-BLOWING MACHINE. Geo. C. Crawford, Bartlesville, Okla.

1,039,755. OPERATING MECHANISM FOR FRICTION-CLUTCHES. Charles B. King and Clarence B. Weston, Marion, Ohio.

1,039,757. COMPRESSOR. John C. Kitton, Elgin, Ill.

1,039,809. TUNNELING-MACHINE. Lebbeus H. Rogers, New York, N. Y.

1,039,840. SAND-BLAST MACHINE. John J. Strasser, Chicago, Ill.

1. The combination of a reservoir for comminuted material, a substantially horizontal tubular member for the outward flow of the comminuted material, said tubular member being arranged at the lower part of the reservoir and having an opening to the outside air and also an opening within the reservoir for the admission of the comminuted material, said last mentioned opening being on the under side of said tubular member whereby it is prevented from being choked by the material within the reservoir.

1,039,842. PNEUMATIC PUMP. Martin S. Swanstrom, Chicago, Ill.

1,039,958. AIR-LIFT. Frank J. Kimball, Los Angeles, Cal.

1. An air-lift comprising, in combination with a well casing, a tubular pump head connected to the lower end of said casing, and provided with an air chamber, means for supplying compressed air to said chamber, and a plurality of nozzles extending upwardly from said chamber and opening at their lower ends into said chamber and opening at their upper ends into the interior of the tubular pump head at different levels.

1,039,971. DOWN-HOLE HANDLE-SUPPORTED ROCK-DRILL. John George Leyner, Denver, Colo.

1,039,972. AIR-CONTROLLING VALVE FOR ROCK-DRILLING ENGINES. John George Leyner, Denver, Colo.

1,040,112. PNEUMATIC WEIR-SHUTTER. John Ashford and Stephen Leggett, Amritsar, India.

1,040,114. PNEUMATIC-CUSHIONED WHEEL. Irwin H. Babcock, De Ruyter, N. Y.

1,040,123. OZONIZER. Harold E. Beck, Chicago, Ill.

1,040,218. PROCESS OF PURIFYING CRUDE GAS. Howard Lane, Birmingham, England.

The herein described process of purifying crude gas which consists in first compressing the gas to a pressure of several atmospheres and then causing the gas so compressed to flow in contact and concurrently with an oppositely flowing stream of water through a mass of comminuted neutral material.

1,040,221. FLUID-OPERATED DRILL-STEEL-GRIPPING VISE FOR DRILL-BIT-SHARPENING MACHINES. John George Leyner, Denver, Colo.

1,040,222. AIR-BRAKE MECHANISM FOR LOGGING-TRAINS. George H. Libby and Harry L. Turney, Portland, Oreg.

1,040,231. PUMP. James M. McWilliams, Leesville, La.

1. A pump including a submerged cylinder, an air pump communicating with said cylinder, a discharge pipe communicating with said cylinder, and having a check valve, an outlet valve in said discharge pipe, a spring controlled lever adapted to normally hold said outlet valve closed, and a connection between said lever and the air pump piston serving to open said outlet valve upon movement of the piston to operative position.

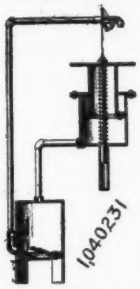
OCTOBER 8.

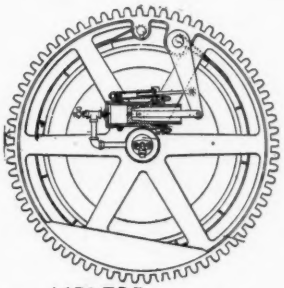
1,040,302. PNEUMATIC - DESPATCH - TUBE APPARATUS. EDMOND A. FORDYCE, Boston, Mass.

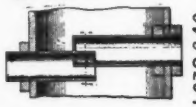
1,040,311. AIR-SUPPLY DEVICE FOR FIREMEN. JAMES D. HALLORAN, New York, N. Y.

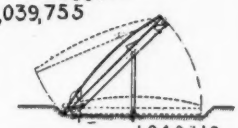
1. In an air supply device, the combination with fire hose having a nozzle, an air suction device exteriorly connected with the said nozzle at the discharge end thereof for drawing in air by the passage of the water through the nozzle, a main air supply pipe connected with the said suction device for drawing in air through the air supply pipe independent of the said fire hose, tapping means connected with the said main air supply pipe for tapping the latter for air, and distributing means connected with the said tapping means for distributing the tapped air to the firemen for breathing purposes.

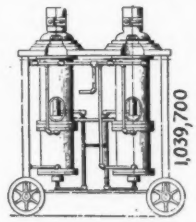
1,040,350. APPARTUS FOR PRODUCING FLUID-PRESSURE. JOSEPH F. KEYS, Gypsum, Kans.

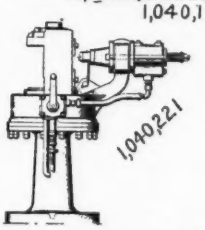



1,040,356. APPARATUS FOR DETERMINING THE AMOUNT OF CARBON DIOXID IN THE AIR. LOUIE E. KNOTT, Boston, Mass.

1,040,434. AERIAL-VEHICLE STABILIZER. LAURENCE O. SCHOPP, St. Louis, Mo.

1,040,499. AIR - PURIFYING APPARATUS. WILLIAM G. R. BRAEMER, Camden, N. J.

1,040,544. ROCK-DRILL. CHARLES A. HULTQUIST, Los Angeles, Cal.

1,040,641. VACUUM-CREATING APPARATUS. MARK F. COYLE, Corry, Pa.

1,040,643. APPARATUS FOR INFLATING ROTATING TIRES. RICHARD E. DARNLEY, Huddersfield, England.

1,040,679. METHOD OF MINING COAL AND OTHER MINERALS. JOSEPH H. HOADLEY, New York, N. Y., and WALTER H. KNIGHT, Portsmouth, R. I.

1. The method of mining coal and other minerals, which consists in comminuting the said mineral in the act of taking it from its bed, depositing the product in the path of a swiftly moving body of air, drawing the said product through the agency of said air into a closed conduit, wetting the product, conveying it while in this condition to a separating chamber, withdrawing the air from the wetting product, and then permitting the mineral to separate from the water by the operation of gravity.

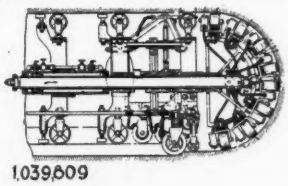
1,040,766. COMPOUND VALVE AND STARTER. CHARLES C. ROTH, Indianapolis, Ind.

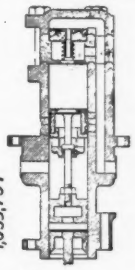
1. In a valve to prevent back pressure through pipes supplying air under pressure to the cylinders of explosive engines, a cylindrical valve case having a reduced discharge end in which a valve seat is formed, an outwardly opening valve in said seat, a spring to normally seat said valve stem extending inwardly of the case, a cap on said case, a piston mounted in the case and seated against the cap and a second spring weaker than said first spring to press the piston against its seat in the cap.

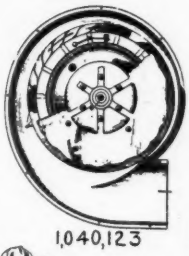
1,040,773. AIR-DOUCHE. AUGUST SCHAEFFER, Frankfort-on-the-Main, Germany.

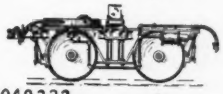
1,040,846. FLUID-PRESSURE BRAKE FOR RAILWAY-CARS. EDWARD A. BARBER, York Pa.

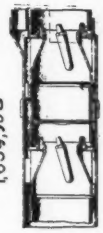
1,040,873. AUTOMATIC AIR - RETAINER.

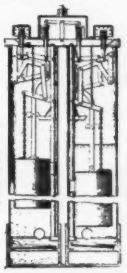





PNEUMATIC PATENTS, OCTOBER 1.

1,040,356. APPARATUS FOR DETERMINING THE AMOUNT OF CARBON DIOXID IN THE AIR. LOUIE E. KNOTT, Boston, Mass.

1,040,434. AERIAL-VEHICLE STABILIZER. LAURENCE O. SCHOPP, St. Louis, Mo.

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1,040,846. FLUID-PRESSURE BRAKE FOR RAILWAY-CARS. EDWARD A. BARBER, York Pa.

1,040,873. AUTOMATIC AIR - RETAINER. LEONARD L. BROWN, Clifton Forge, Va., and JOHN FRANKLING SMITH, Ronceverte, W. Va.

1,040,886. PROCESS OF RECOVERY OF VOLATILE LIQUIDS. GEORGES CLAUDE, Paris, France.

1. A process of recovery by liquefaction, volatile liquids contained in the condition of dilute vapors in large volumes of air or gas, which consists in compressing the air or gas containing the vapors to be recovered, submitting it to a preliminary cooling by means of cold water, then circulating it in indirect contact with air or gas previously expanded and cold in order to liquefy the volatile portions, so that the liquids formed run toward spaces which are warmer than those in which they are liquefied, finally allowing the air or gas thus freed from volatile matters to expand, and using it for cooling successive quantities of the air or gas containing the volatile vapors to be recovered.

1,040,981. EXHAUSTER OR COMPRESSOR FOR GASES, ALSO APPLICABLE AS AN EJECTOR-CONDENSER. WILFRED HUNT, Hillhead, Glasgow, Scotland.

1. An air or gas exhauster or compressor or an ejector-condenser, comprising a stationary direc-

tor and an ejector device, a rotary centrifugal returner arranged to receive an extraining liquid from the ejector, subject the same to centrifugal action and pressure to effect the separation of the entrained gases from the liquid and discharge said liquid to the stationary director, so that said liquid travels a circuit, in combination with means for maintaining the amount of the entraining liquid, an entrance for entrained air or gas and a discharge port for the separated air or gas.

OCTOBER 15.

1,041,057. PNEUMATIC-HAMMER DEVICE. LOUIS G. FISCHER, Harrisburg, Pa.

1,041,091. AIR-BRAKE APPARATUS. OSCAR JOHNSON, Chicago, Ill.

1,041,125. PNEUMATIC ACTUATING UNIT. NELS MAGNUSON, Fort Wayne, Ind.

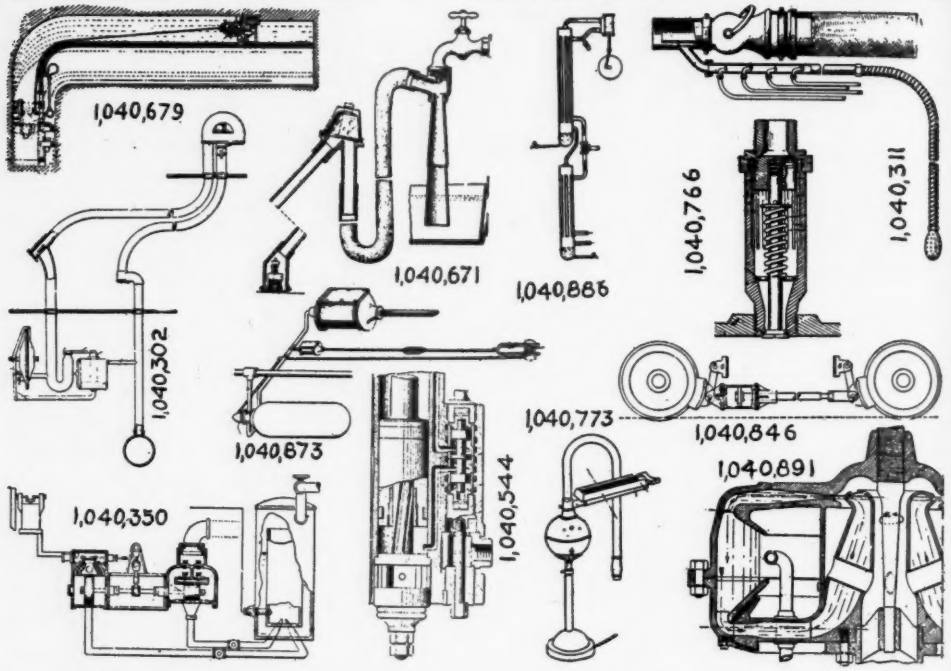
1,041,529. MEANS FOR REGULATING CENTRIFUGAL COMPRESSORS. RICHARD TROGER, Charlottenburg, Germany.

1,041,569. PERCUSSION-TOOL MACHINE. FRANZ BADE, Peine, Germany.

1,041,634. VACUUM-PRODUCER. WILLIS L. KING, Phenix, R. I.

1,041,640. SUPPLYING FUEL AND WATER TO BOILERS. HERMANN LEMP, Lynn, Mass.

1. In combination, a vapor generator, a burner for heating the fluid in the generator, means for supplying fluid to the generator, a controller for the fluid supply, means for supplying fuel to the burner, a controller for the fuel supply, a source of compressed air supply, and a regulator responsive to variations in the pressure in the generator for regulating the supplying of compressed air from said source to said control-




PNEUMATIC PATENTS, OCTOBER 8.

1,041,156. METHOD FOR ASCERTAINING THE LOCATION OF LEAKS IN UNDERGROUND FLUID-PRESSURE PIPES. GEO. V. PAYNE, Chicago, Ill.

1,041,323. APPARATUS FOR REMOVING MOISTURE FROM AIR. JOHN B. MILES, Philadelphia, Pa.

1,041,336. PNEUMATIC-PRESSURE GAGE. OLE OLSEN, Oakland, Cal.

1,041,391. AIR-BRAKE COUPLING. OLIVER P. WILHELM, Michigan City, Ind.

1,041,421. PROCESS FOR OZONIFYING. CHAS. S. BRADLEY, New York, N. Y.

The process of ozonifying, which comprises effecting an ozonifying electric discharge in a gas at a pressure materially below atmospheric, whereby the impedance to the travel of the charged particles of the gas is diminished

1,041,487. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. AUGUST DE KLEIST, North Tonawanda, N. Y.

1,041,505. CENTRIFUGAL COMPRESSOR. SANFORD A. MOSS, Lynn, Mass.

1,041,511. CENTRIFUGAL COMPRESSOR AND PUMP. RICHARD H. RICE and SANFORD A. MOSS, Lynn, Mass.

lers to cause the latter to vary the supply of fluid and fuel to the generator and burner respectively.

1,041,661. BRAKE DEVICE FOR ROLLING-MILLS. ADOLF ALEXANDER KARL NOWAK, Bous-on-the-Saar, Germany.

3. A rolling mill having a mandrel rod, a compressed air device for advancing the same, and a fluid brake employing a non-compressible fluid, co-operating with the mandrel rod to halt its advance at a predetermined point, substantially as described.

1,041,693. DUPLEX AIR-COMPRESSOR. SIMON K. STEFFY, Harrisburg, and HOWARD H. NAYLOR, Marietta, Pa.

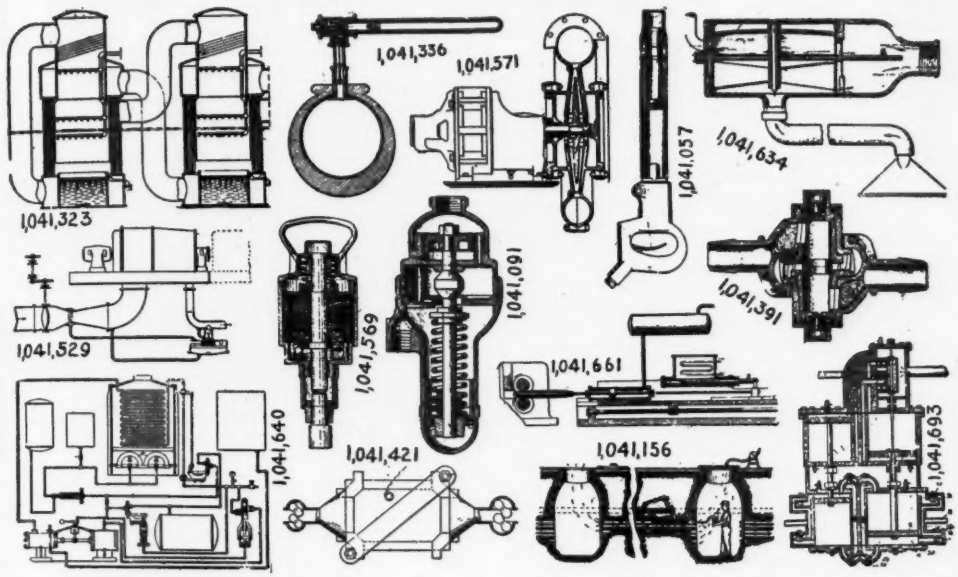
OCTOBER 22.

1,041,744. PNEUMATIC TRACK-SANDER. ANTHONY S. CONTI, Chicago, Ill.

1,041,860. MUSIC-SHEET-GUIDING DEVICE. JAMES O'CONNOR, New York, N. Y.

1,041,861. TEMPO-REGULATOR. JAMES O'CONNOR, New York, N. Y.

1. A pneumatically operated musical instrument including in combination, a movable member for modifying the musical effect controlled




PNEUMATIC PATENTS, OCTOBER 15.

by a perforation or group of perforations in a music sheet and plurality of pairs of oppositely acting pneumatics the members of each pair of which act conjointly, all operatively connected with said movable member.

1,041,939. AIR COMPRESSOR AND PUMP. GEORGE P. ABORN, Boston, Mass.

1,042,055. VACUUM-CLEANER. JOSEPH THEISEN, Grand Rapids, Mich.

1,042,106-7. LIQUID-STORAGE SYSTEM. HORACE E. GRANT, Pittsburgh, Pa.

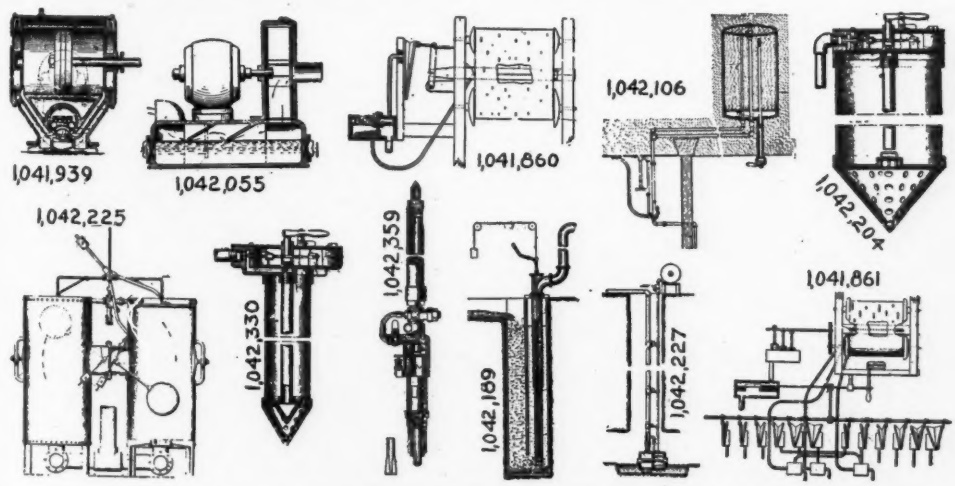
1. In a liquid storage and supply system, a storage tank, an outlet pipe leading from the storage tank, an air pressure pipe leading into said tank from a source of air under pressure, and a single valve having ports which control both the outlet pipe and the air pressure pipe; said valve also having a port arranged to connect the outlet pipe with the atmosphere, and thereby admit air to the outlet pipe adjacent to the discharge side of the valve when the valve is closed, substantially as described.

1,042,189. APPLIANCE FOR RAISING SOLID BODIES. FRANZ BEDUWE, Liege, Belgium.

1. In an apparatus of the character described, the combination with a pit or receptacle for water and granular or fragmentary solid material, of an elevator comprising a sectional tube that extends into the receptacle, the lower intake section of said tube being telescopically connected with the section above it, a conduit extending into and connected with the intake section of the tube for supplying air under pressure to said intake section, and a counterbalance connected with said conduit.

1,042,204. WELL-PUMPING APPARATUS. JOHN W. DARLEY, JR., Baltimore, Md.

1,042,225-6. PUMPING APPARATUS. HASCAL A. HOGEL, Boston, Mass.




PNEUMATIC PATENTS, OCTOBER 22.

1,042,227. COMPRESSED-AIR WATER-ELEVATOR. HASCAL A. HOGEL, Boston, Mass.

1. In a compressed air water elevator, the combination of an air pipe; a casing provided with a plurality of chambers connected to said pipe; means by which air under pressure may be admitted to one of said chambers and allowed to leak into the other; a water delivery pipe; and a connection between said air pipe and water delivery pipe above said chamber, substantially as described.

1,042,330. WELL-PUMPING APPARATUS. JOHN W. DARLEY, JR., Baltimore, Md.

1. A well pumping apparatus comprising an outer tube, adapted to admit liquid at its lower end, a cap normally closing the upper end of said tube and provided with liquid delivery and air exhaust ports, respectively, and also with an inlet passage for compressed air, an inner tube projecting downward into said outer tube and connected at its upper end to said air passage in said cap, valves normally closing said air passage and said liquid delivery and air exhaust ports, respectively, and a hand operated cam arrangement controlling said valves, substantially as described.

1,042,442. FLUID-PRESSURE-ACTUATED HAMMER. NICKLAUS W. ISELI, Milo, Ohio.

1,042,471. PROCESS OF RENOVATING BUTTER. JOHAN D. OUDSTEYN, Chicago, Ill.

1. The process of renovating rancid butter or oil consisting in passing a blast of steam through the melted butter or oil while confined in a chamber free from air and from which the steam is being exhausted continuously while the blast is in operation.

1,042,512. MOTIVE-FLUID-OPERATED TOOL. DANIEL SHAW WAUGH, Denver, Colo.

1,042,627. GREASE-GUN. WILLIAM U. WATSON, Chicago, Ill.

3. In a grease gun, in combination, a cylinder, a piston therein, a hollow piston rod projecting through the end of the cylinder and having a port communicating with the inside of the cylinder at a point above the piston, and means for controllably introducing compressed air and other gases into the cylinder through the piston rod.

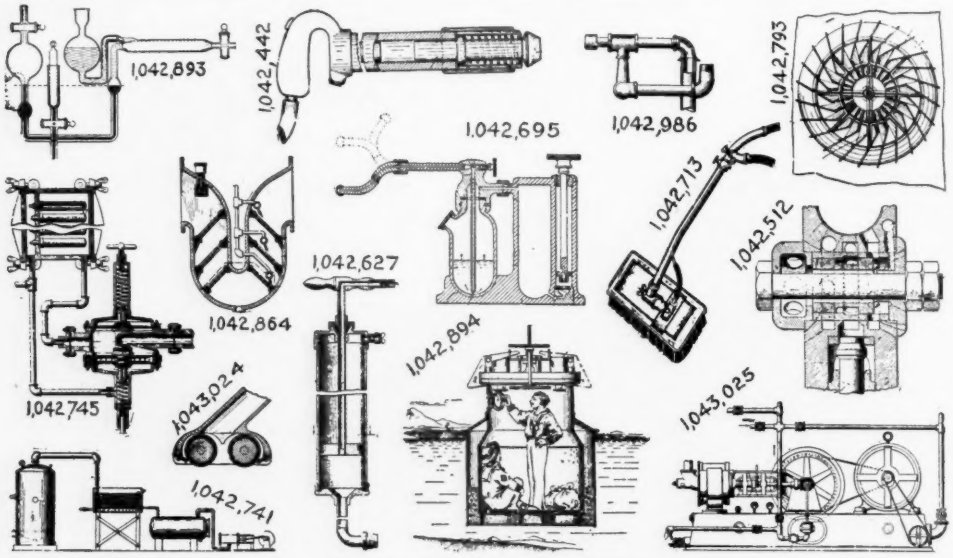
1,042,685. ATOMIZER. GEORGE J. KELLEY, Attleboro, Mass.

2. In an atomizer, the combination of a casing, an air pump in the casing, a compressed air reservoir in the casing adjacent the pump, a liquid receptacle in th casing adjacent the reservoir, said casing being provided with air connections between the pump and reservoir and between the reservoir and the receptacle, a liquid tube in the casing extending into the receptacle, a bore in the casing above the tube, an air channel leading from the tube to the bore and a valve in the bore extending into the air channel.

1,042,711. VACUUM CLEANING DEVICE. ALBERT E. MOORHEAD, Chicago, Ill.

1,042,713. PNEUMATIC SCRUBBING APPLIANCE. ALBERT E. MOORHEAD, San Francisco, Cal.

1,042,745. PRESSURE-REGULATOR. EDWARD ZAHM, Buffalo, N. Y.




PNEUMATIC PATENTS, OCTOBER 29.

1,042,359. ROCK-DRILL. EDWIN M. MACKIE, Chicago, Ill., and PERCIVAL F. DOYLE, Franklin Pa.

OCTOBER 29.

1,042,403. GAS AND AIR MIXING METER. GEORGE R. COTTRELL, Anglesea, N. J.

1,042,442. FLUID-PRESSURE-ACTUATED HAMMER. NICKLAUS W. ISELI, Milo, Ohio.

1,042,471. PROCESS OF RENOVATING BUTTER. JOHAN D. OUDSTEYN, Chicago, Ill.

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1,042,745. PRESSURE-REGULATOR. EDWARD ZAHM, Buffalo, N. Y.

1,042,795. APPARATUS ARRANGED ON LOCOMOTIVES AND OTHER POWER-PROPELLED VEHICLES FOR UTILIZING THE RESISTANCE OF THE AIR. JULIUS JAENSCH, Breslau, Germany.

1,042,864. APPARATUS FOR TREATING AIR. WALTER HAMILTON WINKS, Baltimore, Md.

1,042,893. HUMIDOSTAT-REGULATOR. WILLIAM M. CLARK, Washington, D. C.

1,042,894. LIFE-PRESERVER. ABNER D. CRULL and LEONARD SPANGLER, Indianapolis, Ind.

1,042,956. GLASS-DRAWING APPARATUS. TRAVIS OAKES and DANIEL RESSLAR, Mount Vernon, Ohio.

1,042,980. PRESSURE-REGULATOR. HARVEY E. SHAWVER, Lewiston, Ill.

1,043,024. PNEUMATIC CLEANSING IMPLEMENT FOR REMOVING DUST. ALBERT E. MOORHEAD, San Francisco, Cal.

1,043,025. PNEUMATIC CLEANSING APPARATUS. ALBERT E. MOORHEAD, Chicago, Ill.

1,043,040. PULSATOR FOR MILKING-MACHINES. ANDERS LASSEN BERTHELSEN, Brædstrup, Denmark.

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# COMPRESSED AIR MAGAZINE

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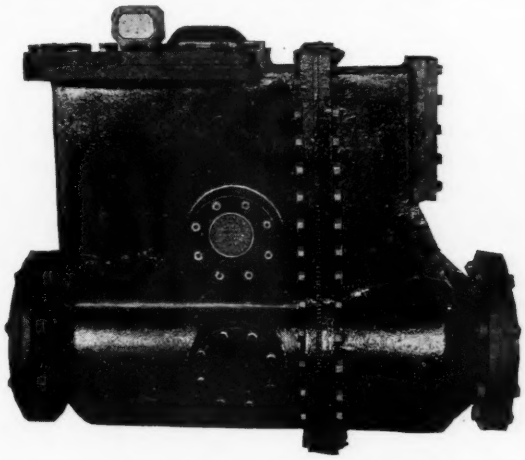
DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

Vol. XVII DECEMBER, 1912 No. 12

## The Westcott Air Meter

**A Displacement Meter with readings given in cubic feet of Compressed Air**

*You read this Meter the way you read your watch*



Accurate measurement range from 1 to 2 per cent up to full rated capacity

**Not affected by external jar or vibration**

Made in capacities for small departments or large factories.

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**METRIC METAL WORKS**

Established 1888 **Erie, Pa.**

Published by THE COMPRESSED AIR MAGAZINE CO., Easton, Pa.

NEW YORK, Bowling Green Building LONDON, 165 Queen Victoria Street

Classified Buyers' Guide, Pages 12, 14, 15 and 16 Index to Advertisers, Page 8.

# GOODRICH HOSE

**AIR DRILL**
**PNEUMATIC**
**STEAM**
**SUCTION**

VALVES for all purposes.
Goodrich Quality.
Goodrich Service.
Why not benefit by our experience?

## The B. F. GOODRICH CO.

**AKRON, Ohio**

*The World's Largest Rubber Factory*

TRADE MARK

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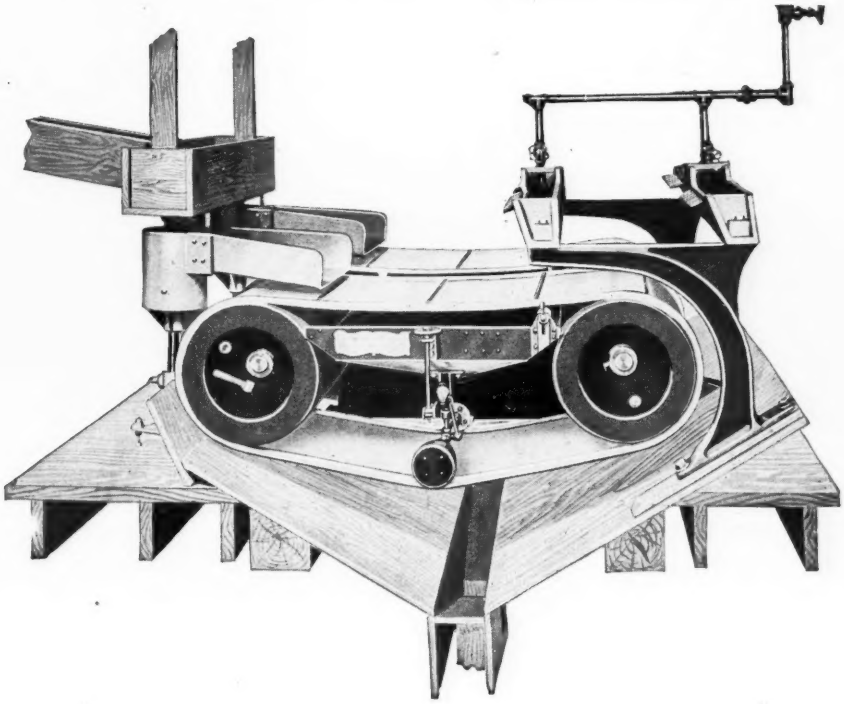
# The Callow Traveling Belt Screen

**For Accurately Sizing Finely Crushed Materials**



It is becoming the common practice, in concentrating plants treating zinc ores, where high grade products are required, to screen size the table tailings on **Callow Screens** retreating the screen undersize and rejecting the oversize, thus materially increasing percentage of extraction. Screen sizing off-setting the errors of hydraulic classification.

**HOW ABOUT YOUR TAILINGS?**

If effective on zinc ores why should it not be on other classes of ores? Make a hand screen test on your tailings and investigate this feature, then write us.

## The Galigher Machinery Co.

**SALT LAKE CITY, UTAH, U. S. A.**

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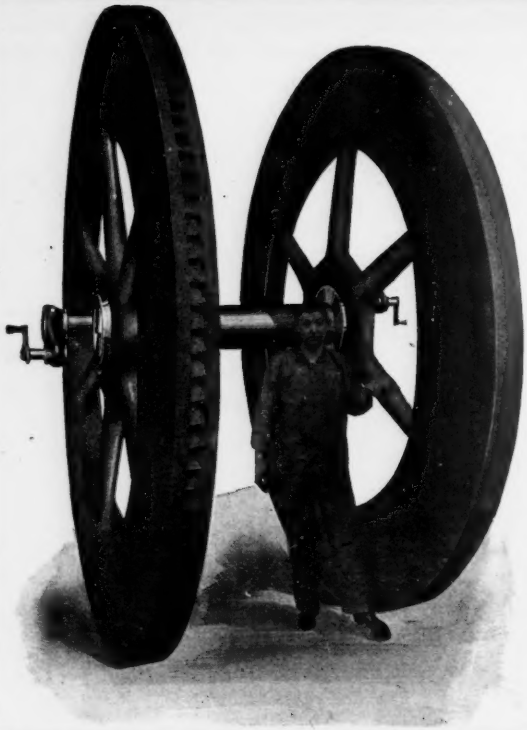


# LOW AIR COST

When your motive power is steam, you can compress air at lowest cost with

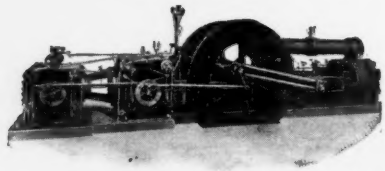
**Sullivan Tandem Corliss Compressors**

Heavy fly wheels secure smooth operation at all speeds.

Bulletin 958-D.

## SULLIVAN MACHINERY CO.

**122 SOUTH MICHIGAN AVE., CHICAGO, ILLINOIS**



TRADE PENBERTHY MARK.

# Automatic Injectors

**SELF-DRAINING AND RE-STARTING**

*A copy of our new magazine "Injector Talks," will be sent free.*

25 years' experience in injector construction has made the Penberthy Automatic the world's most efficient boiler feeder.

Over 625,000 of these injectors have been made and sold during the last quarter century.

**PENBERTHY INJECTOR CO.**
**Detroit, Mich., U. S. A.**

# Dixon's Pipe Joint Compound

will be found better than red or white lead for the making up of all threaded connections.

Dixon's Compound is a lubricant rather than a cement and so not only assists in making tight joints, but permits of easy disconnection.

Booklet 188-D free on request.

**JOSEPH DIXON CRUCIBLE COMPANY**
**Jersey City, N. J.**

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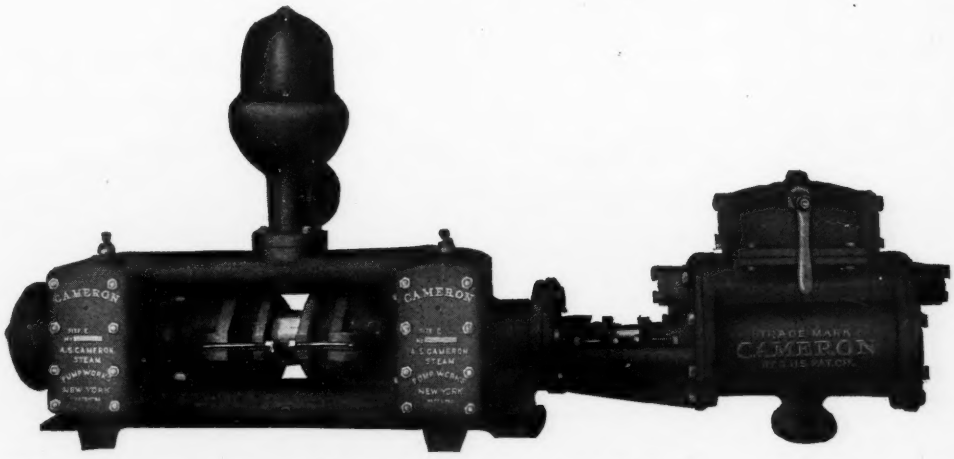
*The Slogan of the Cameron:—"Character: The Grandest Thing."*

# Cameron Pumps

## ALWAYS WORK WHEN YOU WANT THEM TO




## The Cameron Outside-Packed Plunger Pump

(ILLUSTRATED)

gives excellent service in handling gritty water. It is more durable than a piston pump. There are no wearing parts in the water cylinder except the packing in the stuffing boxes, which can be instantly adjusted from the outside. Moreover, it has no working parts exposed to rust or damage either from carelessness or accident, and as the plunger works in loose sleeves the pump barrel cannot be cut or worn by grit or sand.

Above all, it is a compact pump with all parts ready and easy of access, and it is cheapest in the long run, as its HIGH EFFICIENCY is long lived. If you desire to pay the lowest price for EFFICIENT PUMP SERVICE, install the CAMERON.

*Complete Catalog No. 11 will be mailed on request.*

# A. S. CAMERON STEAM PUMP WORKS

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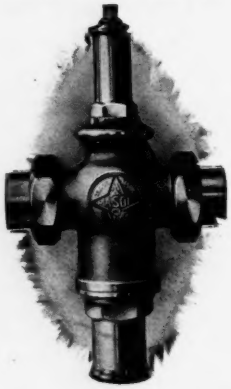
# MASON
## Reducing Valves
ARE THE WORLD'S STANDARD



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**Steam, Air or Water**

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**Mason Regulator Co.**
**Boston, Mass., U. S. A.**

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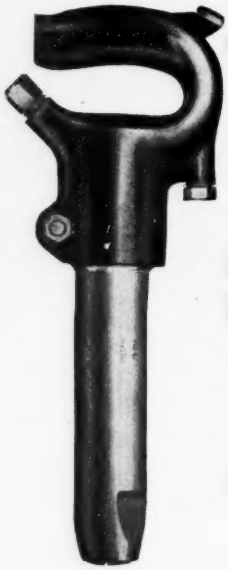
## CHIPPING, CALKING RIVETING HAMMERS



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ALL GUARANTEED AND SENT ON APPROVAL

**GEO. OLDHAM & SON COMPANY**

PNEUMATIC TOOLS AND APPLIANCES

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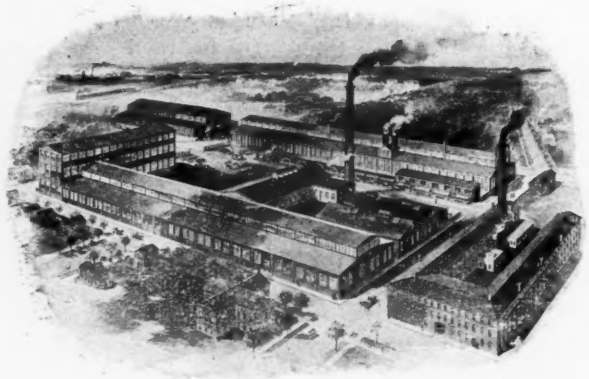
**Frankfort, Phila., Pa.**

# The C. & G. Cooper Company
## ENGINE BUILDERS

Steam Engines 50 to 10,000 H. P.



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**Ingersoll-Rand Co.**

**New York** **London**

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Clean-Washed Material Permits Accurate Sorting

The "CRANE"

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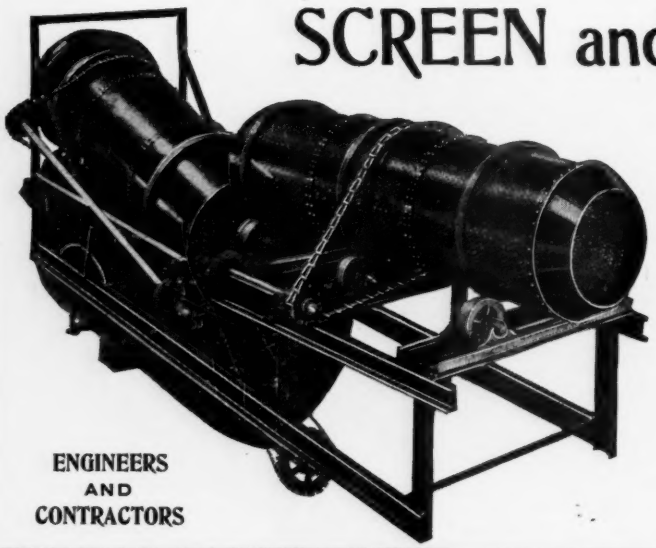

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Rich "Fines" by Screening
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Complete Plants for Concentration, Cyaniding, Chlorination and Smelting of Ores.

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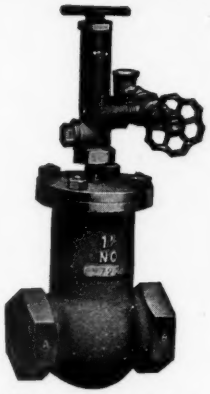
For Single, Duplex and Multiple Stage
Steam, Belt or Electric Driven

**AIR COMPRESSORS**



Maintains practically a constant air pressure, whatever the requirement. Completely unloads and loads Compressor without shock or strain.
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## POWELL Air Gun Valve

Blows your work bench, machine tool, in fact everything, perfectly clean. Operation is another case of "Press The Button." Order a sample.

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For Air Cylinders of Electric-driven Compressors.

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For steam Cylinders of Compressors.

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For Air Cylinders of Steam-driven Compressors.

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For Steam Cylinders of Compressors

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For Bearings of Compressors.

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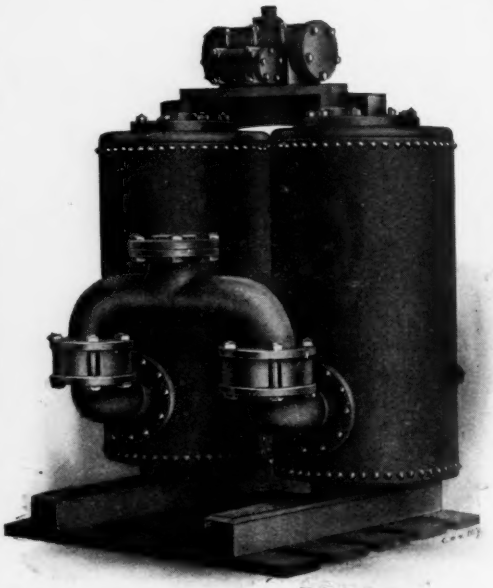
## The Latta-Martin Pneumatic Displacement Pump



The Culmination of 15 Years' Experience

### FOR LONG-DISTANCE PUMPING

**Sold Under an Absolute Guarantee**

Has no pistons or plungers to cut or wear out, requires no lubrication. Handles muddy or gritty water without injury.

Utilizes power at plant and pumps water from any distance – no independent pumping station necessary.

Have been sold with repeat orders from the U. S. Government, the British Government, State Governments of New York, Indiana, Maryland and many of the largest railway systems and manufacturing plants in the world. Handles water, oils, acids, sewage, marl, slurry and all silicious mixtures. For mines and quarries it has peculiar advantages over all other methods of pumping.

The manufacturers have built and sold more than ten times as many displacement pumps as all other displacement pump builders in the world.

**Latta - Martin Pump Co.**

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*High Grade Hose*

*for Steam, Air Drill, Suction, Water, etc.*

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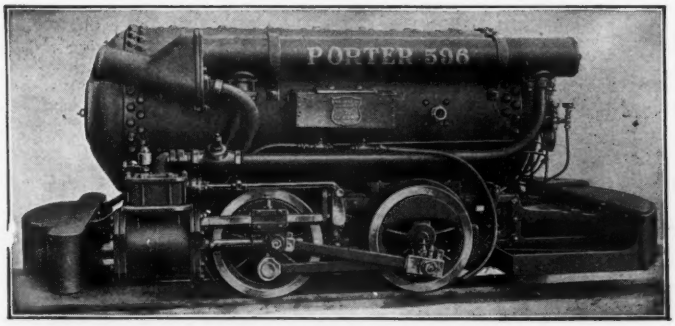
## MINE AND INDUSTRIAL HAULAGE




A Two-Stage Compressed Air Gathering Locomotive—one of twenty built for the Pittsburg-Buffalo Company. Wireless, Sparkless. Two-stage features add fifty per cent. to the efficiency and reduce the cost of installation, making our air haulage the most economical as well as the safest, cleanest, handiest and most dependable mine haulage in the world.

Address **H. K. PORTER COMPANY, 1207 Union Bank Bldg., Pittsburg, Pa.**

# Compressed Air Locomotives

**Locomotives of Every Description**
**for Mine and Industrial Service**

# The Baldwin Locomotive Works

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# McNab & Harlin Manufacturing Company

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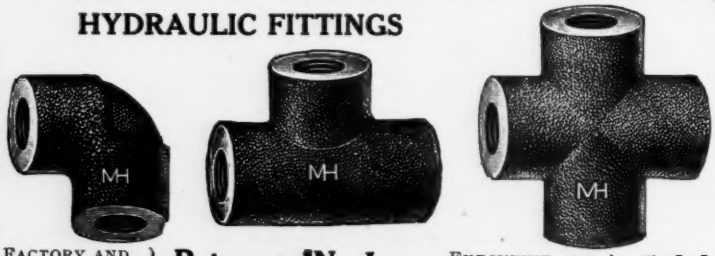


All our Hydraulic Fittings and Valves are made from Special Hydraulic Metal, and we guarantee them to stand 1,000 to 10,000 pounds pressure per square inch.

Many years experience, the best equipment and thoroughly up-to-date methods of inspecting, testing and finishing have enabled us to produce PERFECT fittings.

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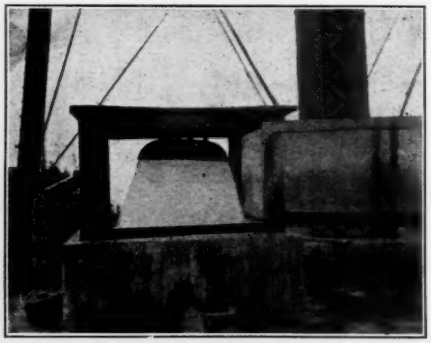

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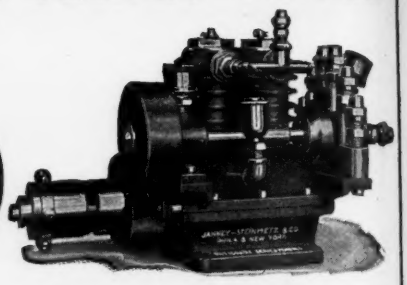

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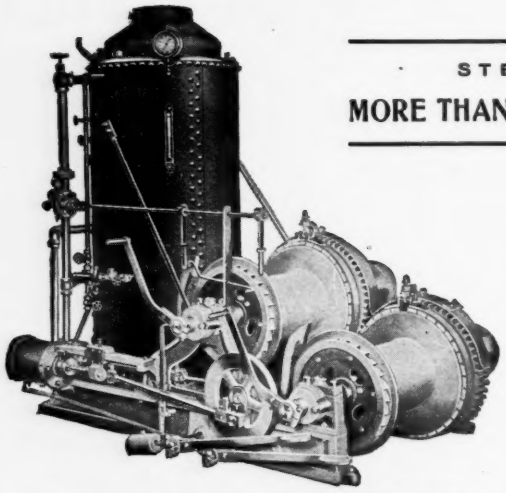

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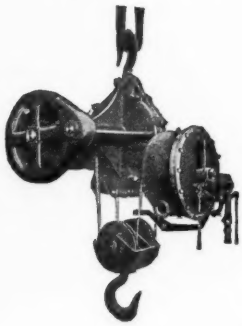

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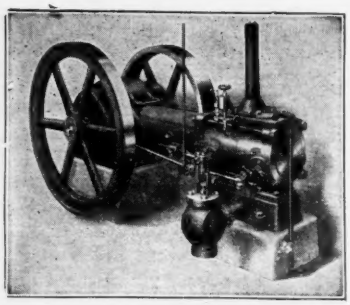

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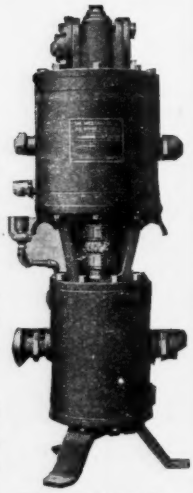

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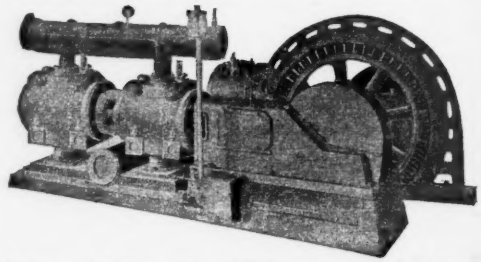

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